The Auditory Centre: Research and Design of Acoustic Environments and Spatial Sound Projects

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I, Lawrence Harvey, declare the following;

a) except where due acknowledgement has been made, the work is mine alone;

b) the work has not been submitted previously, in whole or in part, to qualify for any other academic award;

c) the content of the thesis is the result of work which has been carried out since the official commencement date of the approved research program;

d) any editorial work, paid or unpaid, carried out by a third party is acknowledged;

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Abstract

Design culture is tentatively embracing the acoustic conditions and auditory awareness of spaces and objects, thus creating new opportunities for spatial sound practitioners. This thesis examines the making of seven spatial sound design projects in diverse milieux and an eighth project – the establishment of an electroacoustic studio within a school of architecture and design. The projects and the studio are considered models for the ways in which electroacoustic practices might advance the auditory spatial awareness of students and researchers in the academy, and the general community through an interlocking program of teaching, research and events. The creation of the projects and establishment of the studios also articulate a transformation in my own practice from composer to design researcher. Five of the projects are intended to engender in listeners a greater awareness of the acoustic environment and the auditory spatial qualities of those environments, which listeners daily inhabit. Supporting these project studies is a discussion on issues and conditions of making and materials to elucidate my approach to creating spatial sound designs in diverse milieux. Two of the projects investigated the auditory spatial awareness of different communities in Melbourne, with the view of establishing ideas about the auditory culture and the actual environments of that experience. The final project is a facility to house a community of practitioners who aspire to privilege the auditory design and experience of space, through a series of research, teaching and performance activities. While evaluating just how my practice transformed over the course of the projects, I also propose that the combination of the Studio's main elements is critical to the advancement of sound-based research and design as a design discipline.

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Introduction

The milieux in which sound designers practice have expanded in number and type. The causes for this expansion can be located in three domains. The first domain is the emerging notion of the acoustic environment from the mid-20th Century to the present, which has been part of a wider concern with human-environment relationships. The second has been technological, through the development of ever more sophisticated software, and hardware tools for the capture, reproduction, and production of acoustic environments. For the first time in human history the acoustic conditions of the physical world can be measured, partially captured and reproduced across time and space. Disciplines encompassing science, engineering, medical, communication and media research are grounded in the use of electroacoustic technologies. The third domain is the specific application of those technologies for the creation of spatial sound designs, which has led to the concert hall being relegated to just one of many contexts in which auditory works are made for public audition, and artists realise their ambition to enact change on the acoustic environment.

This expanded number of milieux brings the work of electroacoustic sound designers into closer contact with the quotidian lives of the general community, new collaborative partners, and other professional disciplines. New relationships are formed with listeners. Where sound was once a material exclusive to music, it is now a material for design.

In this PhD, I have aimed to undertake and investigate a transformation in my own practice from that of a composer-sound artist working predominately in artistic milieux, to a sound designer-researcher based in a school of spatial studies. The culmination of this transformation is the establishment of a new electroacoustic studio in a design school. Three central themes are woven through this transformation and investigated in this thesis. The first theme is the creation of spatial sound designs for public, cultural and virtual spaces, using electroacoustic technologies. The second theme is the auditory qualities of urban environments and the experience of listeners in the spaces of everyday life. If sound designers are to work in an expanded number of milieux then an understanding of the auditory spatial experience of listeners will provide insight into the complex relationships that listeners have with acoustic space, and inform the type of acoustic design interventions that designers might enact in urban environments. The third theme is concerned with the making and materials of spatial design practice and its position as an emerging spatial discipline. This third theme merges much of the previous two, and culminates in a project to create a community of spatial sound practitioners and a specialist sound design facility. These themes were the basis of seven practice-based research projects undertaken between 1999 and 2005, and an eighth concluding project that commenced in 2004 and is ongoing at the time of writing in 2007. Each of the projects was undertaken in diverse milieux that include large-scale urban soundscape systems, visual art galleries, a virtual reality centre, concert halls, game engines and drama theatres. The project titles, locations, and presentation or key dates are shown in Table 1.

	Projects	Event location	Dates
1	*SoundSites*	Span Galleries, Melbourne, Australia	9 - 30 October 1999
		Seymour Centre, Paralympics Art Festival, Sydney, Australia	16 - 28 October 2000
		SoundTravels – Toronto, Canada	9 - 12 October 2003
2	*Canopies* installation	Southgate Arts and Leisure Precinct, Melbourne, Australia	18 January – 21 April 2000
3	*Symbiosis*	Virtual Reality Centre, Melbourne, Australia	21 - 30 July 2001
4	*Canopies: concert version*	CREATE, Santa Barbara, U.S.A	17 May 2001
		ACMA Conference Melbourne, Australia	7 July 2001
		Livewire, NSW Conservatorium of Music, Sydney, Australia	20 November 2002
		AFAE Conference, Melbourne, Australia	22 March 2003
5	K	Melbourne International Arts Festival, Melbourne, Australia	23 October – 2 November 2002
		Wiener Festwochen, Vienna, Austria	8 - 11 May 2003
		Seoul Performing Arts Festival, Seoul, South Korea	13 - 16 October 2005
6	*Ecstasis*	RMIT Virtual Reality Centre, Melbourne, Australia	Ongoing from 2003 until 2004
		John Curtin Gallery, Biennial Electronic Arts Perth, Perth, Australia	10 September – 12 December 2004
		Ars Electronica, Linz, Austria	7 September 2004
		Architectural Biennial, Beijing, China	20 September – 6 October 2004
		Experimedia, State Library of Victoria, Melbourne, Australia	13 July – 18 September 2005
7	*CitySounds*	Project goes 'live' and access for public, Melbourne, Australia	12 August 2004 – 31 March 2005
		Launch of final report, State Library of Victoria Melbourne, Australia	7 February 2006
8	*SIAL Sound Studios*	Commence development, RMIT University Melbourne, Australia	July 2000
		Official opening, Horti Hall *Spectrum 01*, Melbourne, Australia	3 - 4 December 2004

Table 1: The projects' presentation and key dates

The first seven projects are considered as test beds from which I distil insights on sound design as a spatial practice. As acts of making, these projects informed the eighth project presented in Chapter 6, the establishment of the SIAL Sound Studios at RMIT University's School of Architecture and Design. The earlier projects are windows into the future operations of the Studio, which I consider to be acts of design that transcend the usual technical focus of traditional computer music. Finally, I evaluate my practice and role of the Studios as an expanded one that encompass the process of making spatial sound design, collaboration with arts and non-arts communities, developing an activist role to the soundscape, creative mediation, and research and curatorial endeavours in academic, professional and public domains.

To situate the origins of this practice, I first draw together in Chapter 1, two parallel histories; the rise of the notion in Western thinking of the acoustic environment and the emergence of electroacoustic spatial sound design. This chapter also contains a brief discussion of approaches to sound other than traditional acoustics in schools of architecture and design. In Chapter 2, I outline five of the seven spatial sound projects – *Canopies installation, Canopies: concert version, K, Symbiosis* and *Ecstasis* – all completed between 1999 and 2005 in diverse milieux. The discussion is limited to the completed form of the projects, with analysis of their making and auditory spatial qualities following in Chapters 3 and 4. The theme of auditory qualities of urban environments is taken up in Chapter 5, with a description and evaluation of the two projects – *SoundSites* and *CitySounds* – investigating the auditory experience of listeners in everyday environments. Chapter 6 puts forward a model for a community of practice in spatial studies, whose primary focus is the creation of spatial sound designs and the conditions of the acoustic environment. The conclusions in Chapter 7 identify the attributes of how my practice transformed through the projects and into the establishment of the Studios.

While my work draws on previous research in soundscape studies, electroacoustic and computer music, it is differentiated from these fields primarily through application. My position is that current electroacoustic practices if applied to design research, pedagogy and practice, can be considered aural-centric forms of making with the potential to expand designers' knowledge of auditory spatial experience. If sound-based designers are to collaborate successfully with established design and architecture disciplines, then it is pivotal that other designers fundamentally understand spatial sound designers practice. To that end, the audience for this thesis includes the immediate one of sound-based practitioners, especially those seeking a process for transforming their practice into another domain, as well as an expanded field of designers concerned about the aurality of spatial experience. For other design-based readers, this thesis is intended to convey knowledge of how a sound designer considers sound as a material for the project of creating large-scale spatial sound works. Compared to other more established design disciplines, the conceptual frameworks for thinking about acoustic space in spatial sound design have a relative short history. However, the emerging practices and concepts around spatial sound design could be the provenance of new thinking about human experience in the environment.

Note on accompanying materials

This thesis draws on extensive documentation generated during and after completion of the projects, in the form of images, figures, tables and sounds. The spatial sound projects are presented either wholly or in reduced form on the accompanying CDs and DVD. In some instances, for example the *Canopies installation*, it was not feasible to reproduce the project except in reduced format or sound 'mock-up'. The following table shows the original format, the format presented for this thesis, and the duration of the materials. All examples are stored on the accompanying DVD. The audio examples use a purpose built player for integrating mixed format audio examples and graphics. Instructions for starting the application appear on cover of the DVD.

	Projects	**Original format**	**Format for thesis and location on DVD**	**Duration for thesis**
1	*SoundSites*	*Stereo*	*Stereo files inside folder titled Sound example 33 SoundSites*	*55 minutes*
2	*Canopies* installation	*160 loudspeaker soundscape system*	*Eight channel mix at Sound example 2 in 02_LHplayer_scoreDisplay and Video example 1 Canopies site installation.mp4*	*6 minutes and 49 seconds*
3	*Symbiosis*	*8 channels*	*Original eight channel mixes at Sound examples 4, 6, 8, 10, 13 and 15 in 02_LHplayer_scoreDisplay and Video example 2 Symbiosis installation.mp4*	*48 minutes*
4	*Canopies: concert version*	*Stereo*	*Stereo mix at Sound example 17 in 02_LHplayer_scoreDisplay*	*12 minutes 15 seconds*
5	*K*	*Multiple sources mixed live over 3 quadraphonic systems*	*Video example 4 K performance excerpt.mov*	*9 minutes*
6	*Ecstasis*	*8 channels*	*Eight channel mix at Sound example 22 and Video example 3 Ecstasis exhibition.mp4*	*16 minutes*
7	*CitySounds*	*Games engine*	*Stills in printed thesis*	

Table 2: Format of thesis sound examples

Where sound examples relate to discussion in the body of the thesis they are indicated by a text box as follows:

Sound example 1: This is the title of sound example 1.
In most instances, descriptive text for the example appears here.

1.0 The acoustic environment and electroacoustic spatial composition

Introduction

The concept of the acoustic environment has only recently appeared on what Margaret Wertheim refers to as the: "human psychic landscape" (Wertheim 2000, p. 306). As with other spatial concepts, it is sustained through a community who research and make audible spatial concepts. Initially in parallel to, and eventually intertwined with the development of acoustic environment research has been the production of spatial electroacoustic music.

Histories, theories and contemporary practices associated with acoustic environment research and spatial electroacoustic music have been influential on the projects undertaken for this thesis. The provenance of the acoustic environment can be traced to individual researchers prior to 1970, but the field was advanced through work undertaken by a series of loosely connected groups from around this time to the present day. The work of experimental composers producing an expanding scale of projects eventually arrived at the design and construction of temporary buildings for the performance of electroacoustic acoustic works. In the period 1958 - 1970 electroacoustic music benefited from advances in electronics and computing, culminating in a vast array of equipment and software solutions for individual practitioners. The field of acoustic environment research is now generally held to be widely interdisciplinary, encompassing acoustics, psychoacoustics, otology, noise abatement, communications, sound recordings and engineering, aural pattern perception, structural analysis of language and music, sociology, anthropology, psychology and geography (Schafer 1994, p. 3; Truax 1999, entry for Soundscape Design).

In this chapter, I first locate the notion of the acoustic environment in Western thinking, through acoustics, key research groups and topics, and a study of a non-Western relationship to a soundscape. To position electroacoustic spatial composition, I first trace the initial production of multi-channel electroacoustic music from 1950 to 1977, before turning to an overview of contemporary research and practices. The two streams merge in the third section in a discussion on the design and auditory awareness of acoustic space, how spatial concepts are maintained, the role of acoustic space and the impact of technology, before turning to a wider consideration of health and social factors in relation to the acoustic environment. As I consider these themes central to sound design as a spatial practice, section 1.4 of this chapter contains a short examination of spatial sound studies in schools of architecture and design. The transformation of my own practice took place in one of these schools, so I end by briefly discussing aspects of my work up to the commencement of the projects described and analysed in Chapter 2.

1.1 Soundscape studies and notions of acoustic space

The rise of acoustics and the signal model of sound

Technological developments in the 20th Century changed human relationships to the sounding world, and were the impetus for new disciplines and spatial concepts. Until the advent of audio recording media in the early to mid-20thCentury, the sounds around us were fleeting. There was no way of capturing, and holding this part of the phenomenal world for further investigation or communication. One attribute of audio recording, as compared to text based, data or visual representations of an individual sound or acoustic environment, is that it recreates, to variable degrees of accuracy, the energy-spectral profile of the original sound to our ears. Early monophonic representation of the materials of the auditory environment initially held little spatial information, or spatial representation. However, recording technologies of capture, editing, manipulation and diffusion that propagated more widely from the 1950s were quickly followed by ideas about acoustic space, and enabled the composition of spatial electroacoustic music. To a degree, these technologies made stable that which had previously been ephemeral and fleeting.

These new technologies were in no way a benign influence on the auditory experience of listeners in the early Twentieth Century. Emily Thompson's *Soundscapes of Modernity* (2004) shows how a new "… clear, direct efficient, and non-reverberant …" sound came to signify the sound of the modern age. This new sound was efficient, as it contained no unnecessary elements to encumber clarity, and communicated directly to those that could thus respond more productively. It was a product defined by the act of consumption and it also demonstrated man's "technical mastery over his physical environment" transforming "traditional relationships between sound, space, and time" (Thompson 2004, p. 4). Thompson weaves her narrative between the architectural, social and technical developments in early Twentieth Century North America that saw buildings erected specifically for film, music, radio, commercial work and hotels, all conforming to these new auditory conditions. Thompson's thorough and provoking thesis challenges the reader to rethink how the urban environment is formed by arguing for a history that is seen and heard in the buildings of the past. Furthermore, the issue of noise and technology is addressed in her work, by demonstrating how "musicians and engineers created a new culture out of the noise of the modern world" (Thompson 2004, p. 9). Later in the text, Thompsonquoting Dreher, observes that sound production in early motion picture work was primarily undertaken by researchers and technicians from the emerging telecommunications industries, initially telephony and later radio (Thompson 2004, p. 284). Their auditory preferences were for the clear intelligible signals of spoken word, decontextualised of any space or spatial attributes. In this new age, sound becomes information.

Concepts of information

As the concept of information is influential on emerging notions of the acoustic environment, it is worth briefly considering perspectives on its role in human consciousness. Cybernetics might, in fact, be defined as "the study of systems that are open to energy but closed to information and control — [that is] systems that are 'information-tight'" (Ashby 1957, p. 4). Ashby later states:

> The most fundamental concept in cybernetics is that of 'difference', either that two things are recognisably different or that one thing has changed with time… All the changes that may occur with time are naturally included, for when plants grow and planets age and machines move some change from one state to another is implicit. So our first task will be to develop this concept of 'change', not only making it more precise but making it richer, converting it to a form that experience has shown to be necessary if significant developments are to be made (Ashby 1957, p. 9).

The notion of difference raised here by Ashby returns again in Bateson's notion of difference, and can be observed at the basis of the CRESSON approach discussed below. Cybernetics offers the hope of providing effective methods for the study, and control of systems that are intrinsically extremely complex (Ashby 1957, pp. 5-6).

> The term itself [cybernetics] began its rise to popularity in 1947 when Norbert Wiener used it to name a discipline apart from, but touching upon, such established disciplines as electrical engineering, mathematics, biology, neurophysiology, anthropology, and psychology. Wiener, Arturo Rosenblueth, and Julian Bigelow needed a name for their new discipline, and they adapted a Greek word meaning 'the art of steering' to evoke the rich interaction of goals, predictions, actions, feedback, and response in systems of all kinds (the term 'governor' derives from the same root) [Wiener 1948]… the relevance to social systems and the softer sciences was also clear from the start. Many researchers from the 1940s through 1960 worked solidly within the tradition of cybernetics without necessarily using the term, some likely (R. Buckminster Fuller) but many less obviously (Gregory Bateson, Margaret Mead). (Pangaro 2006, para. 4).

Glanville (1997) describes an important component of emerging practices around the study of environments, mechanisms and perceptions, that is, the status and place of the observer. His description of the observer in cybernetics resonates with that of the listener in classic acoustic ecology:

> Included in mechanism, it was found, was the mechanism of observation that allowed the mechanism of the 'system' (or whatever you like to call it) to be

> determined, and the mechanism that made such describing possible: as well as the mechanisms that permitted there to be observation and, indeed, an observer to make the observation. The observer (traditionally excluded in accounts based in mechanism) became an integral part of the system under consideration and observation became an inclusive and included process. Questions of what is inside and outside were no longer clearly answerable: the system no longer had an independent existence, which lead to a revision of the status of what was knowable (Glanville 1997, para. 14).

The notion and role of information is also a defining characteristic of soundscape studies. In the entry for communication in the *Handbook for Acoustic Ecology*, Truax (1999) first provides the classic Shannon-Weaver model of information exchange of 1949 (see Figure 1) in this definition:

> The idealized communication system comprises six elements: source, transmitter, channel, message, receiver, and destination. Because communication means a sharing of elements of behaviour or modes of life, it necessarily involves sets of rules for the exchange of such information. Such sets of rules comprise the communication code and are designed to bring about a discriminatory response from the person or device receiving the message. At each stage of the message transfer, noise can occur (Truax 1999, entry for Communication).

Truax then notes that the contemporary study of communication has:

> … shifted from a model based on signal transfer to one based on information exchange, a shift that is similar to the difference between hearing and listening, or the difference between acoustical engineering and soundscape studies (Truax 1999, entry for Communication).

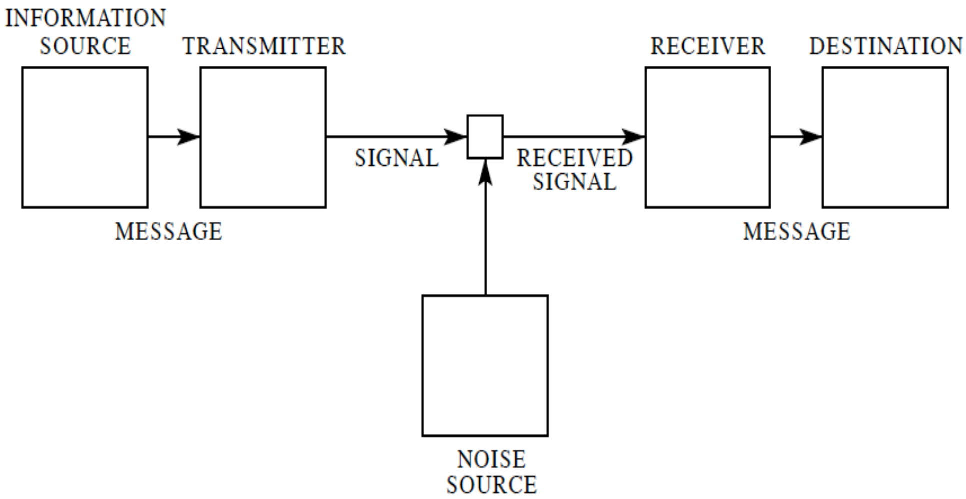

Figure 1: Schematic of general information system

This schematic appeared in Shannon's A Mathematical Theory of Communication (Shannon 1948, p. 2). *Compare the essentially linear nature of this diagram, to later schematics describing acoustic space and auditory spatial concepts in the diagrams of Figure 2.*

Information theory and music were brought together, through the French theorist Abraham Moles in his book *Information Theory and Esthetic Perception* (Moles 1971). Moles was closely associated with French electroacoustic composers, attending meetings of the Bourges Symposium of electroacoustic music (Clozier 1998, p. 197). Moles' use of information theory has been influential on composers and electroacoustic practitioners since the 1970s, especially those involved in computer composition and performance, concerned with establishment of criteria and assessment of research outputs, deemed to be compositions, sound synthesis techniques, or simulation of voice or musical instruments.

Gregory Bateson (1972) has provided the most succinct definition of difference, but to do so, he first determines what is the unit of mind, by invoking a metaphor of a map and territory. He asks what is it in the territory that makes it onto the map of our minds. The answer he gives is 'difference'. That is, maps are constructed from differences, differences in altitude, vegetation, or the difference in a population structure, or the differences in a surface. However, a difference is "an abstract matter" (Bateson 1972, p. 452). In communication, effects are brought about by differences, whereas in the hard sciences, he considers that effects are caused by concrete physical conditions or events such as impacts, forces and energy exchange. In thinking about communicational processes, Bateson puts forward that analogies of energy theory will not hold. He suggests "that the word 'idea', in its most elementary sense, is synonymous with 'difference'" (Bateson 1972, p. 453). Following a Kantian line of reasoning, Bateson notes there are an infinite number of possible 'facts' existing in the objects with which we interact in a day.

However, he modifies this suggesting instead that there are an infinite number of differences between objects and their environment, between objects and their location or condition. But as agents operating in environment, we select from this infinitude, a small set of these differences, which becomes information. Bateson's well-known maxim on difference from *Steps to an Ecology of Mind*:

> In fact, what we mean by information – the elementary unit of information – is a *difference which makes a difference*, and it is able to make a difference because the neural pathways along which it travels and is continually transformed are themselves provided with energy. The [neural] pathways are ready to be triggered. We may even say that the question is already implicit in them (Bateson 1972, p. 453. Italics are original).

The notion of the acoustic environment differs from models of other sound-based disciplines, particularly acoustics, primarily through the notion of information, and the presence of an observer as a critical part of an environmental study. That is, the listener is actively engaging with the environment, constructing meaningful information from the stimulus via auditory faculties. Bateson's suggestion to put aside energy models resonates with Truax's communication model for sound discussed in more detail next, and with the CRESSON model of the sonic effect which seeks to differentiate experience-forming events and architectural features in the acoustic environment. The notion of the acoustic environment arose within an intellectual climate concerned with the idea of information and its use by observers in that environment. Where music and phonetics had been the primary conveyors of meaning within auditory perception, the whole soundscape now became a focus of study, enveloping other disciplines.

The notion of the acoustic environment: acoustic ecology, sonic effects and sonic ethnography

As it is possible to geographically locate the emergence of perspective representation in 15th Century Florence, the emergence of the acoustic environment grew from a Canadian spatial sensibility in the 20th Century. Since the 1960s, several new terms to describe those aspects of the world experienced through the ear have appeared, such as 'acoustic space', 'auditory space', 'acoustic environment' and 'soundscape'. The genesis of acoustic space is discussed in Richard Cavell's (2002) extensive study of Marshall McLuhan. Cavell's study reviews McLuhan's oeuvre as an extended spatial essay, particularly as McLuhan and his close friend and colleague Edmund Carpenter consider acoustic space as having:

> … no point of favored focus. It's a sphere without fixed boundaries, space made by the thing itself, not space containing the thing. It is not pictorial space, boxed in, but dynamic, always in flux, creating its own dimensions moment by moment. The eye focuses, pinpoints, abstracts, locating each object in physical space, against a background; the ear, however, favors sound from any direction. We hear equally

> well from right or left, front or back, above or below. If we lie down, it makes no difference, whereas in visual space the entire spectacle is altered. We can shut out the visual field by simply closing our eyes, but we are always triggered to respond to sound (Carpenter and McLuhan 1970, p. 67).

This notion of acoustic space had a profound effect on McLuhan's thinking about media and experience. Cavel notes that: "…McLuhan's interpretation was that in communication there is no transportation of information (concepts or 'content') from a source to a target, but a transformation of the source and target simultaneously" (Cavel 2002, p. 5 quoting de Kerckhove). In saying this, Cavell notes that McLuhan's idea of communication combines "a spatial model with a sensory one, McLuhan [is] insisting that media were extensions of our senses" (Cavell 2002, p. 6). Furthermore, the effects of any medium on our sensory lives, "is to do with changes in the perception of space, in that space was the medium of communication: uttering as outering" (Cavell 2002, p. 6).

The term 'acoustic space' appears as the title of an essay by McLuhan and Carpenter, predating the initial publications of the *World Soundscape Project* by almost ten years[1], and R. Murray Schafer's *The Tuning of the World* by 17 years. *Acoustic Space* is a spare 2300 wordpiece in which the authors traverse a multitude of topics and themes that would set the agenda followed by researchers in the acoustic environment for the next forty years. The essay broaches visual perception, anthropology, linguistics, psychology and psychoacoustics, child development, historical comparison, poetry and sound and sensory fusion. It critiques visual language where an auditory word is either inferred, or its usemore efficient. Inter-cultural differences are invoked – between Eskimo and Western notions of silence and the emphasis on visual over aural reality in Western thinking. The development of vision in the child, and learning to resolve spatial attributes such as depth through kinaesthetic exploration are also briefly touched upon. They draw differences in perceptual development between a hypothetical child incapable of motion from birth who would be trapped in a two dimensional world, and with a blind child, who would be fully capable of spatial navigation using aural means: "unimpaired by the hopeless visual conflicts of the hypothetical child, and, more importantly, he can explore this auditory world tactually while in motion" (Carpenter and McLuhan 1960, p. 67). The hypothetical example demonstrates how the child could find the chief characteristic of visual experience – depth – through locomotion and tactile experience indicating that the visual is not required to do what might be called 'learn space'. This short example is one of the most succinct arguments to refute the necessity for visual perception as a space-forming experience. The text ends, with a speculation that:

> … Today we are experiencing the emotional and intellectual jag resulting from the rapid translation of varied visual and auditory media into one another's modalities (Carpenter and McLuhan 1960, p. 70).

1 Although *Acoustic Space* is referenced as 1970, the text was copyright in 1960.

In the notes of Cavell's text (2002, pp. 234 - 235), he gives an account of attempts to establish the existence, then the qualities of acoustic space. Cavell disputes other claims that the behavioural psychologist E.A. Bott devoted his life to studying auditory space, or was the first to use the term.[2] Instead Cavell cites research into the construction of sensory space, from Geza Révész in 1937, *Does an Acoustic Space Exist?* from William James' *The Spatial Quale* of 1879, (although the latter is primarily a discussion on the fusion of the senses), from Henry J. Watt *The Psychology of Sound*(1917), and Hermann von Helmholtz, who Cavell claims McLuhan eventually assigned as the originator of the concept 'acoustic space'. Helmholtz's original study, *On the Sensations of Tone as a Physiological Basis for the Theory of Music* dates back to 1885. In the early part of the 20th Century, the debate revolved around whether the auditory was inherently spatial, or if it achieved spatiality only through association or conjunction with other senses (Watt 1917, p. 175). Cavell's opinion is that McLuhan understood auditory space in sensory interfusional terms.

World Soundscape Project and acoustic ecology

The Canadian connection to acoustic space re-emerges through the work of the *World Soundscape Project* (WSP) founded in the late 1960s. After R. Murray Schafer entered the Royal Conservatorium of Music and the University of Toronto in 1952, he came into contact with McLuhan whose ideas he would later adopt and translate into the emerging discipline of soundscape studies. In footnotes, Cavell (2002, p. 279) mentions that Schafer acknowledged McLuhan's influence on his own work, but it is also evidenced in Schafer's 1985 article *McLuhan and Acoustic Space* (Schafer, 1985). The formation and dissolution of the World Soundscape Project is examined in Keiko Torigoe's Masters thesis *A Study of the World Soundscape Project* (Torigoe, 1982). By 1973, the team directed by Schafer at Simon Fraser University, Vancouver included Peter Huse (Assistant Director), Bruce Davis, Lorraine Cushing, Barry Truax, Howard Broomfield, Colin Miles and Hildegard Westerkamp. Jean Reed is included in the research team photograph taken during a field trip to Scotland in 1975.[3] The WSP was supported by UNESCO, the Canada Council and The Donner Canadian Foundation and their early work included cross Canada and European recording trips, educational books on listening awareness, and a compendium of Canadian noise laws. In 1973, Schafer published *The Music of the Environment* as a critique of acoustic design, mainly drawn from literary sources. Schafer left Simon Fraser University in 1975, leaving Barry Truax and Hildegard Westerkamp to continue the work started by the original group. By 1978, Barry Truax had published the first edition of the *Handbook for Acoustic Ecology*, and continued courses in Acoustic Communication that covered both the soundscape of earlier years and Truax's concepts of electroacoustic communication using technologies for production and analysis.

2 Interestingly, although Bott was working at the University of Canada, he and McLuhan never met (Cavell 2002, p. 234). Carleton Williams first brought the term 'auditory environment' to McLuhan's attention during the seminar McLuhan jointly hosted with Edmund Carpenter. McLuhan and Carpenter later produced the essay on *Acoustic Space.* I also attempted to uncover, with no success, any studies attributed to Bott investigating auditory space, and I am grateful to the Canadian Psychological Association history section for assisting in this search.
3 See photo at <http://www.sfu.ca/~truax/wsp.html>. Accessed February 10, 2007.

In an interview I conducted with R. Murray Shafer and Hildegard Westerkamp (Harvey, 2003a), Schafer spoke about the early years of the WSP and his impetus for studying the acoustic environment.[4] In the following series of quotes, Schafer makes practical comments about the foundation of an interdisciplinary research agenda, and the likely impact of that research agenda through training of new practitioners:

> … In Vancouver, it was a department for Communication Studies, and in those days I guess it was really modelled on the work of Marshall McLuhan, who was very popular at that time as a media guru. It was a new university, and so anything was possible and very few questions were asked. We had space, we had money, and we were able to do almost anything we wanted to do for the first year or two. We were constantly under observation. People were asking, 'well, what are you going to do?'
>
> I'm a composer/musician by training. The thing I felt was absolutely necessary at the time was to begin to study the acoustic environment we lived in [and] the changes that had taken place. Partly out of a campaign against noise pollution which was a real problem for me. I should say as a small footnote… I came from the Eastern part of Canada in which the houses are much better insulated against the cold, so therefore also insulated against extraneous noise. Moving to Vancouver, I was immediately attracted by the noise. Not only by the fact that windows were open for most of the year, but also the walls were a lot less insulated so [there was] a lot more penetration of sound from outside. I become very absorbed by the whole issue of noise pollution, and ran a course on it in 1966 in Vancouver (Harvey 2003a).

Schafer goes on to state that the early courses were totally unsuccessful. He invited experts in the fields of acoustics, law and workers' compensation who would discuss noise from various perspectives. The messages were generally negative and the students taking the course were left feeling desperate in large part and overwhelmed by a perceivedly hopeless situation. Schafer sought a way he could 'flip' the situation around.

> It was then I really developed the concept of the soundscape. The soundscape then for me was the total acoustic environment; all of the sounds around us, without prejudging. So within that concept of the soundscape, let's study all the sounds in our environment; let's then determine what sounds we like, what sounds we want to preserve, what sounds we want to eliminate, what sounds we want to reduce. It was out of that work that we had a grant and gathered together a small research team in addition to teaching a couple of courses – there was only two or three subjects in the course, it was not a 'program'.
> The money, however, was sufficient to hire a research team. Westerkamp was one of the original members, and we set out to do some field studies. The first was the Vancouver soundscape. It was a very big topic, of course. However, we produced a

4 The interview was conducted on March 18, 2003 at RMIT University, Melbourne. The Author holds a recording of the interview.

> book and two LP records which attempted to document the sounds of Vancouver right back to the time before the white people arrived, when it was still a native community. By interviewing people, we managed to get a feeling for the changing shape of the acoustic environment from the time of the original native inhabitants, up to the time of the Project (Harvey 2003a).

Schafer's original vision for the group was that it should be formed from acousticians, musicians and sociologists. The model would be that of the Bauhaus in Germany[5] where the staff comprised craftsmen, artists, architects and designers, but the students emerged as industrial designers. Similarly, the student who would emerge from Schafer's course would be a soundscape designer. A major stumbling block proved to be in hiring. The engineers Shafer approached were either disinterested, or demanded more money than was on offer. The final team was, he says, an "accident" (Harvey 2003a) comprising people from sociology, music and the arts. The team did measure acoustic environments to avoid criticism from the acoustic engineers, as well as conducting many interviews to gain a wide amount of information. Shafer discusses the employment prospects of the graduate:

> To some extent, everyone in a university situation is involved in training people for jobs, and if these jobs exist the program can very easily be created. The soundscape designer that I'm talking about, that job does *not* exist. Where is he or she going to work? Work for whom? They are not going to work in the film studio; they are not going to work in the area of sound technology. They are not going to be working in architecture because the architects are not interested. They are not going to be in social work … or teachers in schools. Somehow, it's a question of creating a program that is then going to unleash onto the world a fleet of people who are probably unemployable (Harvey 2003a).

During the interview, Westerkamp challenges this notion on the basis that the film industry is employing people, the "right architecture firm" will think this way, and urban designers are embracing the acoustic ecology concepts. Westerkamp notes that the jobs in fact exist, but that personnel need to be trained in the direction of sound (Harvey, 2003). While the term 'soundscape' is increasingly heard in wider professional discussions, the practice of acoustic ecology should still retain the original vision of the WSP of synthesising "craftsmanship and artistic production, functionalism and creativity" arising from an interdisciplinary teaching and design practice (Westerkamp 1994, para. 2). The formal definition of acoustic ecology is the study of living beings' relationship to the soundscape. The word 'soundscape' is:

> … derived from landscape. Soundscape is the acoustic manifestation of place, where the sounds give the inhabitants a sense of place and the place's acoustic quality is shaped by the inhabitants' activities and behaviour. The meanings are created precisely because of this interaction between soundscape and people. Thus,

5 Born (1995, p. 100) notes too that Pierre Boulez was also heavily influenced by the Bauhaus as an institutional model when establishing IRCAM.

> the sonic environment (or soundscape), which is the sum total of all sounds within any defined area, is an intimate reflection of - among others - the social, political, technological, and natural conditions of the area. Change in these conditions means change in the sonic environment (Westerkamp 1994, para. 6).

This broad agenda differentiates acoustic ecology from other environmental sound movements such as noise and right-to-quiet movements.[6] While there is some debate about whether a phenomenological approach is appropriate within an ecological framework (Redström 1998), the listener-centred approach of acoustic ecology applied, for example, to the teaching of sound within an architectural programme is particularly useful.

Technology played a major role in the analysis leading to various definitions of what constituted the acoustic environment by the *World Soundscape Project*. The rise of soundscape studies is inextricably linked to the development of auditory representational tools. In this instance, stereo recording and multi-channel tape composition, as opposed to standard acoustical measurement devices. That is to say, listeners placed an emphasis on production and analysis as opposed to data collection and numerical analysis. The rise of electroacoustic music studios and computer tools for analysis was in the ascendancy during the 1960s and 1970s. WSP group member Barry Truax had completed studies in electronic and computer music at the Institute of Sonology, Utrecht before moving to Vancouver. Although the WSP emphasised the direct experiential necessity of acoustic ecology as a unit forming an analytical tool, recording technology was very much in use for documentation and representation. Westerkamp provided this observation on the making of field recordings:

> I think the combination of going out and documenting what you hear, and at the same time perhaps, now with small recording technology (mini-disk), to take that as well, then you have another type of documentation of what was actually there, because the ear will miss certain thingssimply because that is what we do. There is an aspect of using technology that heightens the listening experience and changes it. There is a different type of information [that] happens when you listen, and when you record (Harvey 2003a).

The field of acoustic ecology has established models and theories to describe human relationships to acoustic environments. *The Handbook for Acoustic Ecology* (Truax 1999) establishes a lexicon of layman's terms to describe features of acoustic environments. Within the field, raising awareness of acoustic environments is a central undertaking particularly by sound-walks and soundscape compositions. Furthermore, practitioners from within acoustic ecology have provided the most sustained critique of traditional approaches to issues such as noise and management of the acoustic environment over the last forty years.

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6 For links to other noise activism and right-to-quiet organisations, see <http://www.acousticecology.org/urban.html>, viewed March 31, 2004, <http://www.calm-network.com/>, viewed March 31, 2004, and <http://www.quiet.org/>, viewed March 31, 2004.

The listener-centred approach of acoustic ecology is today attracting an increasing level of interest from disparate fields, including sound and vibration specialists, geographers, urban designers, and behavioural psychologists. The field, and the approach itself, have recently been the subject of papers on interdisciplinary practice (Epstein 2003). Since the formation of the World Forum for Acoustic Ecology (WFAE) in 1993, a series of international acoustic ecology conferences have taken place in Canada, Europe, Japan and Australia. Special sessions on acoustic ecology or soundscape approaches have been organised at the 12th International Congress on Sound and Vibration in Lisbon[7], and the Royal Geographical Society in London. Both conferences took place in 2005.[8] Papers citing the work of the WSP and using soundscape approaches are also appearing in the proceedings of the International Conference on Auditory Display.[9] Members of the WFAE now maintain several primary web resources for Acoustic Ecology[10], Simon Fraser University[11], and the Acoustic Ecology Institute.[12] Regular publications from the WFAE and affiliates also appear each year. Two examples of these include *Soundscape: The Journal of Acoustic Ecology* and *Earshot, the Journal of the UK & Ireland Soundscape Community* (UKISC). The activist approach discussed later is very much in evidence through the activity reports and information provided on these sites. The development of the field can also be observed through the formation of new research groups including the Positive Soundscape Group at University of Salford, UK[13], and the Acoustic Ecology Research Group (AERG) University of Calgary.[14] Both the awareness and educative approach have been adopted for student projects. As with the early WSP, a student project from the University of Guelph, Ontario also focussed on the immediate acoustic environment of the research group.[15]

As acoustic ecology matures and a body of research evolves, critical appraisals of the field and its methodological assumptions are now appearing. In *The History of Soundscape or Soundscape as History?* Gasior (2005) challenges original notions in acoustic ecology: " such as the supremacy of the natural soundscape over the urban sound environment", while recontexutalising ideas from the 1960s and 1970s into the present day, and how forms of "soundscape can be found in film sound design and museum installations" (Gasior 2005). Johan Redström (1998) also presents a challenge to the community in his paper *Is Acoustic Ecology about Ecology?* in which he describes the problems of a phenomenological and an ecological approach. He presents a case that the discipline would benefit from using "a theoretical framework like the theory of affordances or a notion of meaningfulness [which] enables us to

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7 Details are available from <http://www.icsv12.ist.utl.pt/index.php>, and notice of R. Murray Schafer's keynote address appears at <http://www.icsv12.ist.utl.pt/programme/keynote.php>, viewed February 10, 2007.
8 Details including conference abstracts available from <http://www.acoustics.salford.ac.uk/home_pages/adams/Conference%20Session%20RGS2005.htm>, viewed February 25, 2007.
9 See <http://www.icad.org>, and, for one example; <http://www.icad.org/websiteV2.0/Conferences/ICAD2003/paper/36%20Turner.pdf>, viewed February 10, 2007.
10 See <http://interact.uoregon.edu/MediaLit/WFAE/home/index.html>, viewed February 10, 2007.
11 See <http://www.sfu.ca/~truax/wsp.html>, viewed February 10, 2007.
12 See <http://www.acousticecology.org/index.html>, viewed February 10, 2007.
13 See <http://www.acoustics.salford.ac.uk/research/davies_files/projects/soundscapes/positive_soundscapes_home.asp>, viewed February 10, 2007.
14 See <http://webapps1.ucalgary.ca/~acoustic/index2.html#about>, viewed February 10, 2007.
15 See <http://www.uoguelph.ca/~ewaterma/soundwebsite/>, viewed February 10, 2007.

keep the phenomena while acknowledging the many and complex ways of agent world interaction" (Redström 1998). Acknowledging this complexity across several fields of human endeavour has been a path pursued by the extensive work of CRESSON (*Centre de Recherche sur l'Espace Sonore et l'Environnement Urbain*)[16], to document sonic experiences in urban environments.

CRESSON

> *"What instruments are available to technicians and researchers, administrators and users, designers and inhabitants? What is the sonic* instrumentarium *of urban environments?" (Augoyard and Torgue 2005, p. 4).*

In describing the origins of the sonic effect concept, Augoyard and Torgue (2005) note that:

> … the urban sound environment can be subjected to two types of operations: it can be considered as an object of description, or as an object of transformation (Augoyard and Torgue 2005, p. 4).

Before *Sonic Experience* was published in English in 2005, Björn Hellström's *Noise Design: Architectural Modelling and the Aesthetics of Urban Acoustic Space* (2003) provided the first extensive English language introduction to the work of CRESSON, and also to that of Pascal Amphoux, based at IREC (*Institut de Recherche sur l'Environnement Construit*) associated with the Department of Architecture, School of Polytechnic in Lausanne. Amphoux's work *The Sonic Identity of European Cities,* presents qualitative methods and strategies based in architectural, acoustic, sociological and aesthetic actions to specify the sonic identity of cities. CRESSON was founded in the late 1970s, where the research leading to *Sonic Experience* was conducted by a thirty-five member team in the *Centre National de la Recherche Scientifique* (CNRS) laboratory, *Ambiances architecturales et urbaines*, School of Architecture, Grenoble. The sonic *instrumentarium* refers to:

> … a store of sounds, which brings form to social, perceptual, cultural and spatial configurations, and the key to this instrumentarium is to be found in knowledge of sonic grammar (Hellström 2003, p. 21).

The focus of *Sonic Experience* is to provide a series of descriptive tools that sit between two others: the sound object (*l'objet sonore*), and the soundscape. Pierre Schaeffer's *Traité des objets musicaux* (1966) provides a new musicology that could be applied to any sound of the environment. However, Augoyard and Torgue are critical of this tool. Although it is useful for sound design and education, it is not suitable for sounds *in situ,* where each individual sound would need to be described in a potentially unwieldy fashion. The authors critique the

16 The English translation of CRESSON appears as "Sound Space and Urban Environment Research Centre", viewed February 15, 2007, <http://www.cresson.archi.fr/accueilENG.htm>.

soundscape approach as not simply referring to a sound environment but referring to what "is perceptible as an aesthetic unit in a sound milieu" (Augoyard and Torgue 2005, p. 7). Sounds that are part of an environment might be simply dismissed as they do not meet the *hi-fi* criteria of a balanced soundscape. Invoking a linguistic analogy, the authors position the soundscape approach as useful in describing the whole structure of the text, while the sound object tool may describe individual words. The sonic effect approach of their study, working at an intermediary level of sentence grammar, provides a tool that can work "at the scale of everyday behaviour and at the scale of architectural and urban spaces." Eighty-two effects are presented as sixteen major and sixty-six others, and a hierarchy is used to further organise the effects based on three criteria:

- the basic effect and its variation
- effects that always exist in concrete space or in the listening process e.g. reverberation
- effects that directly participate in the nature of the urban environment or cultural process

The major effects are defined in relation to domains where each effect has a primary domain of reference. For example, the first domain is where *Repetition* (Augoyard and Torgue 2005, p. 90) is analysed in sociology and everyday culture, but for *Remanance* it is psychology and physiology of perception. The full list of domains is given as (Augoyard and Torgue 2005, p. 16):

- physical and applied acoustics
- architecture and urbanism
- psychology and physiology of perception
- sociology and everyday culture
- musical and electroacoustic aesthetics
- textural and media

The effects themselves are placed into a taxonomy of five groups, which"allows us to approach [the] sonic effects from a specific point on the two-way loop that connects the physical object to its subjective interpretation" (Augoyard and Torgue 2005, p. 16). The following table summarises the *taxonomy* and individual effects provided in *Sonic Experience*.

Taxonomic category	Description	Example Effect
Elementary effects	Concerned with the sound material itself (pitch, intensity, timbre, attack, duration, etc.)	Filtration, distortion, resonance, reverberation
Composition effects	Concerned with complex sound arrangements defined by characteristics of either the synchronic or diachronic dimension of the context	Masking, release, cut out, drone, telephone
Effects Linked to Perceptive Organisation	Effects due to the perceptive and mnemonic organisation of individuals placed in a concrete situation. Characters that are specific to the culture and the sociability of reference constitute an integral part of the effect	Erasure, synecdoche, remanence, anticipation, metamorphosis
Psychomotor Effects	Implies the existence of a sound action of the listener, or a scheme in which perception and motor function interact.	Chain, niche, attraction, phonotonie
Semantic Effects	The difference in meaning between a given context and its emerging signification. Decontextualisation is always implied, whether it is provoked by shock, humour, or conscious play, or by adding aesthetic value to sound	delocalisation, imitation

Table 3: Taxonomy of sonic effects.

After Augoyard and Torgue (2005) p. 17 of Sonic Experience*.*

The authors suggest the tools can be used for assisting acoustical measurement, a multidisciplinary instrumentation for analysis of complex sound situations, assisting representation, assisting architectural and urban intervention, and as an education tool serving the general experience of listening.

IREC and the auditory identity of cities

Until 2003, the work of Pascal Amphoux and the *Institut de Recherche sur l'Environnement Construit (Irec)* was not widely known in the Anglophonic world. Hellström (2003) provides the first extensive overview of the seminal *Irec* study *L'identité sonore des villes Européennes* (*The Sonic Identity of European Cities*) which had first appeared ten years earlier

(Amphoux 1993). Hellström describes it as a methodological guide that "addresses issues regarding the investigation and description of the sonic identity of European cities. It is not about one method – the work is multi-modal since it embraces different theories as well as methods such as interviews, questionnaires, instrumental and perceptual observations" (Hellström 2003, p. 143-144). The approach is unique as it considers architectural, social and cultural aspects in its method. Hellström later expands on this multi-modal approach where he describes Amphoux's position to other disciplines:

> … the dominant theories that deal with urban sounds are, on the one hand, acoustics and psychoacoustics (basically concerning protection of man from noise), and, on the other, musicology and ethnomusicology (basically concerning the assessment of noise on an aesthetic basis). Amphoux discusses sound-anthropology as a third way of considering urban noise i.e. in accordance with urban sounds' cultural and social meaning, people develop different ways of listening and acting in the built space (Hellström 2003, p. 146).

Amphoux's methodology contains almost eighty criteria in two levels. The *representational* level is to describe objectively the sonic world by developing a vocabulary to do so. The *operational* level is used to describe invention, which "concerns the re-creation of the world in relation to the 'sonic world' (Hellström 2003, p. 145). This level is not intended to bring about solutions to problems of noise, but "concerns the ambition to act on different and incommensurable levels, which Amphoux respectively terms *environnement* (environment), *milieu* (milieu) and *paysage* (landscape). The joint actions between these three levels should be considered." (Hellström 2003, p. 145). Central to Amphoux's approach is the notion of *quality*, used in the sense that an "urban place has a characteristic sonic identity and the city on the whole produces a specific sonic ambience" (Hellström 2003, p. 146). A summary of Hellström's descriptions of the main components of Amphoux's *Sonic Identity* is contained in the following table.

Appealing to the Memory	
Selection of representative places	An emphasis is placed on certain aspects of sounds at each selected place by applying methods of 'Sonic Mind Maps' and 'Phono-Reputable Inquiry'. A theoretical model is used to select these places called the CVS model. CVS is an acronym for *connu* (known), *vécu* (lived) and *sensible* (sensed).
Appealing to Perception	
Constitution of an analytical framework	Analysis of interviewees' responses to sound recordings of the representative places to determine sounds in categories such as 'sonic signals', 'sonic background' and 'sonic ambience'.
Appealing to Interpretation	
Characterisation of the sonic identity of a city	Compilation and interpretation of the results obtained in the previous two approaches. The tool used is a Sonic Identity Chart comprising a repertoire of qualitative criteria which emanates from the three modalities EMP (as in *environnement-milieu-paysage* above).
Application of the method in practice	Three different plans of action being *Diagnosis of the Environment, Managing the Milieu, Creation of the Landscape.*
Methodological Principle of Recurrence	A way to test the validity of data when collecting surveys

Table 4: Main components of Amphoux's Sonic Identity of Cities*.*

From Hellström (2003, pp. 148 - 9 and p. 168).

Amphoux's position is essentially to emphasise the benefits of urban soundscapes, not simply to dwell on the negative effects of sound on local populations. By the early 1990s, Amphoux had studied three Swiss cities – Lausanne, Locarno and Zürich, and the results published in *Aux écoutes de la ville* (Amphoux 1991). Where the work of the WSP focussed first on small villages and concepts that could be transferred between typologies or even media, CRESSON and IREC have focussed specifically on urban environments, including the inter-relation between media, architecture, sociology and urban design. However, the interaction of humans with urban spaces has not been the sole focus of emerging acoustic environment research. Strategies to overcome the bias toward visual experience and representation of space in Western culture have also been a preoccupation of acoustic environment researchers. Steven Feld's research in visually dense rainforest environments has revealed unique relationships in local cultures between environment, music and language that invert the visual bias found in Western settings, providing an alternative voice in auditory spatial studies.

Schafer was not the only sound-based researcher to be influenced by the work of McLuhan and his associates. During his undergraduate studies, Steven Feld came into contact with Edmund Carpenter. Feld recalls that Carpenter and fellow teacher Colin Turnbull put forward a simple hypothesis "that rainforest environments might be the places where humans developed to acute levels of acoustic adaptation" (Feld 1993, para. 3). Feld's interest lay in discovering an ethnography of sound as a symbol system, particularly ways that: "sound and sounding link environment, language, and musical experience and expression" (Feld 1993, para. 3).

Feld conducted his dissertation field research with the Kaluli people of Bosavi, South Central Papua New Guinea in the period 1976 - 77. Feld's study focussed on ritualised vocal expression, principally women's funerary sung as weeping and Kaluli men's ceremonial poetic songs, which have an intimate connection to rainforest birds (Feld 1993, para. 5). Through this study and his time spent on subsequent field trips to the Kaluli, Feld learned:

> … how the ecology of natural sounds is central to a local musical ecology, and how this musical ecology maps onto the rainforest environment. For songs and weeping not only recall and announce spirits, their texts, sung in a poetry called 'bird sound words', sequentially name places and co-occurring environmental features of vegetation, light and sound. Songs become what Kaluli call a 'path', namely a series of place-names that link the cartography of the rainforest to the movement of its past and present inhabitants. These song paths are also linked to the spirit world of birds, whose flight patterns weave through trails and water courses, connecting a spirit cosmology above to local histories on the ground (Feld 1993, para. 6).

Feld's research in the 1990s moved to what he calls "acoustemology", that is, an acoustic epistemology. This acoustic 'knowing' is central to the Kaluli experience of their environment as sounds:

> … emerge from and are perceptually centred in place, not to mention sung with, to, and about places. Just as 'life takes place' so does sound; thus more and more my experiential accounts of the Kaluli sound world have become acoustic studies of how senses make place and places make sense (Feld 1993, para. 13).

Again, Bateson's influence on sound studies appears in Feld's work, as he observes that "linking forest birds and places with voices and experiences was more a search for 'patterns that connect', Gregory Bateson's notion in *Steps to an Ecology of Mind*" (Feld 1993, para. 11). Surprisingly, Feld notes that it wasn't till the early 1980s that he encountered *Tuning of the World* and the publications of the WSP, but Schafer's propositions in the book, that people echo the soundscape in language and music did influence Feld to transform himself from ethnomusicologist, to 'echo-muse-ecologist'. Feld's work has since injected acoustic ecology with a poetic and potent awareness of the degree to which human-environment auditory spatial awareness could evolve. This can be observed in his descriptions of two Kaluli interactions with the environment being 'lift-up-over sounding' and 'flow'. Feld's description of both interactions is complex invoking linguistics, environmental acoustics, sociology, physiology, music and meaning. Lift-up-over sounding is:

> … as potentially omnipresent in the experiences and aesthetics of Kaluli as the notion of 'harmony' is in the West. 'Lift-up-oversounding, like 'harmony, is both a grand metaphor for natural sonic relations, the ways tones combine together in time, as well as for social relations, for people doing things together in concert. In the Kaluli world 'lift-up-over sounding' sounds are dense and layered, blended, and forever thinning and thickening. One hears no unison, only a constant figure to ground motion of densities, decays and fades, of overlapping, alternating, and interlocking sounds … always cohesive, yet always seeming, as well, to be at different points of displacement from a hypothetical unison … [that] define an acoustic space-time where upward is outward (Feld 1993, para. 15).

The Kaluli world is infused with the sound of numerous streams, rivers and waterfalls from Mount Bosavi to the extent that:

> Walking means crossing water, yet always hearing it before seeing it. Water carries in and out of visual perceptual immediacy but always has dramatic, though ever-changing, acoustic presence … This carrying power, moving through and connecting lands, is water's 'flow'. But this 'flow' does not only exist in the way water connects what Kaluli call the 'thighs' (i.e., saddles) and 'body' (i.e., hills) of the land. Water is to land what the voice is to the body. The voice connects the many parts of the body; by resounding in the head and chest, the full body is always present in the 'flow' of the voice, just as the connections of land are always present in the 'flow' of water (Feld 1993, para. 16).

This connection to water continues into the Kaluli use of waterway terms for the "names for the musical intervals, the segments of song, the patterns of rhythm, and the contours of melody" (Feld 1993, para. 17). Musical practice in the form of song composition takes place by waterways with flow being further described by Feld as the process by which a song stays in memory, echoing the way a waterway is continually heard but visually appears, disappears and reappears as one moves through the forest.

> Likewise as one hears a song, it disappears quickly from an experiential foreground and reappears through time in memory, reverberating and lingering in sonic traces and fragments, far past and beyond the moment of an immediate experienced performance. This is how Kaluli songs, like Bosavi waterways, 'flow', emerging in the density of a 'lift-up-over sounding' soundscape of rainforest acoustic ecology (Feld 1993, para. 18).

These quotes reveal the extent to which the auditory experience of place can penetrate the consciousness of a people and their language. There is a precision to the Kaluli connection between language, landscape, music and the soundscape that is no less intricate than that revealed by the CRESSON studies of urban environments.

Defining auditory terms, models and associated practices

The approaches to acoustic environment research described so far have in common the experience of the listener as opposed to the objective measurement and analysis of sound energy. In *Acoustic Communication,* Barry Truax (2001) proposes two models to define different sound-based discipline groupings. The first of these is the energy transfer model which:

> … deals with acoustic behaviour as a series of energy transfers from source to receiver. It examines how these transfers occur, how efficient they are, and what variables affect them (Truax 2001, p. 5).

Truax notes that with the advent of electronic technologies, the model has transformed into a signal transfer one. Specific disciplines associated with this model include architectural acoustics, acoustical engineering, audio engineering and psychoacoustics. In each, the desired goal is either to investigate or control sound waves and audio signals so the desired stimulus will arrive at the listener, while undesired noise will be limited to quantities not obscuring the original signal. Truax argues that the limitations of these approaches are:

> [that]they do not lead to design criteria that go beyond the question of the appropriate control of signals to ask what kind of environment is desirable, meaningful, or beneficial (Truax 2001, p. 13).

His critique of this linear chain of transfer model is made to show its limits in addressing contemporary issues and to argue for the interdisciplinary model of a communicational approach. In this model, the goal is to establish useful criteria for '*acoustic design'* (italics are Truax's), which he says:

> … seeks to modify the functional relationships within the listener–environment system. It may involve changing the sound environment itself, but because the listener is always included in the system, it may also involve modifying the listener or thinking habits of the listener as part of the design strategy (Truax 2001, p. 14).

Whereas in the energy model, hearing is the processing of acoustic energy, listening in the communicational model is defined as "the processing of sonic information that is usable and potentially meaningful to the brain" (Truax 2001, p. 11). The sonic environment in an energy model "can be regarded as the aggregate of all sound energy in any given context" (Truax 2001, p. 11) while the notion of the soundscape in the communication model places an emphasis on how humans living and contributing to that environment understand that environment and participate in its formation through information exchange (Truax 2001, p. 11). Context plays a role in the communicational mode, whereas the energy model demands measurement of sound made regardless of the social and cultural context. The communicational model also deals with "systems of related elements operating at different hierarchic levels" (Truax 2001, p. 12) as it mediates and creates relationships between listeners and the environment, including all three components of a sound-environment-listener circular relationship.

The contribution of disciplines associated with the energy model is applied where the communicational model is potentially generative of design criteria, leading to the emergence of acoustic design as an interdisciplinary practice. Truax rightly notes that architectural acoustics, acoustic engineering and audio engineering have produced vast amounts of knowledge on the ways to control sound waves and audio signals, with the goal of maximising auditory clarity and minimising noise in any system. However, the lived world rarely presents a simple relationship to which a linear response can be applied. Instead, Truax argues for an approach that could create new models and theoretical frameworks for thinking about sound-related problems through the dual modes of design and listener education.

Barry Blesser (2007, pp. 4-5) puts forward a series of terms to define contemporary notions of sound and sound-based practices. Some of the less common invoke architectural meanings. An *aural architecture* defines the properties of a space that can be experienced by listening, where the aural architect is acting as both artist and social engineer, to determine specific aural attributes of a space considered against what is desirable in a particular cultural framework. An *acoustic architect* is a builder, engineer or physical scientist who implements the aural attributes previously selected by the aural architect. Acoustic design includes the manipulation of physical objects, spatial geometries, and mathematical equations from physics. The acoustic architect is working with Truax's energy model, focussing on how the physical properties of the space change sound waves, whereas the aural architect focuses on the experience of listeners in the space. Blesser includes the term "cultural acoustics". While in some cases, it is possible to identify an aural architect, aural architecture is mostly the result of "incidental consequences of unrelated sociocultural forces" (Blesser 2007, p. 5), or decisions made by "architects, space planners, and interior designers with little appreciation for the aural impact of their choices." Blesser posits that one adopts the role of aural architect when we adapt our behaviour or exert control over the acoustic conditions that will affect our aural experience in some way (Blesser 2007, p. 5).

Aural architecture is also closely related to the creation of virtual or illusory spaces making a useful link to the creation of electroacoustic music compositions, performances and installations. But the continued cultural presence of aural architecture and associated concepts has been problematic, due mainly to the nature of sound itself. Blesser gives four reasons for this situation, namely that: "aural experiences of space are fleeting as we lack the means for storing their cultural and intellectual legacy…" in institutions, for example a museum of sound to act as a central repository and "the language for describing sound is weak and inadequate…"; modern culture is visually focussed with little appreciation for the sounding world, and: "…attaches little value to the art of auditory spatial awareness; and finally, professional schools have little or no concern with: "... physical acoustics, aural aesthetics, or sensory sociology" (Blesser 2007, p. 6). The widespread popularity of wearing headphones while negotiating physical space disengages many listeners from their immediate architectural, urban or natural soundscape. Instead they occupy a personal acoustic world that is self-curated. Dr Michael Bull's recent research into this phenomona has revealed the motivation of listeners to drawback from the urban environment.[17] Bull's thesis is that the visual world has itself become so overwhelmingly noisy, that our psychic wellbeing is relient on self-regulation of our auditory experience, mediated through headphone listening.

Truax's acoustic designer like Blesser's aural architect not only practice in the domain of manipulating materials and objects, but also in mediating social relationships, of taking part in awareness raising and educational endeavours. That is, the available interventions to this type of discipline practitioner embrace, but are not limited to the engineering and technological. I will return to this role in discussions of the *CitySounds* and *SoundSites* projects.

Another influential model to emerge that describes auditory phenomena is Albert S. Bregman's notion of the auditory stream. Bregman notes that:

> Sound is created when things of various types happen. The wind blows, an animal scurries through a clearing, the fire burns, a person calls. Acoustic information, therefore, tells us about physical 'happening' (Bregman op cit, p.10).

Each of these "happenings" is a perceptual unit, which Bregman refers to as a "stream", and not a "sound" for two reasons. A physical happening can incorporate more than one sound and "our mental representations of acoustic events can be multifold in a way that the mere word 'sound' does not suggest" (ibid). His second rationale is that the word "sound" is used for both the physical sound in the world and our mental experience of that same sound. Bregman proposes that the word *stream* be used for the perceptual representation and *acoustic event* or *sound* for the happening in the physical world. At the time of *Symbiosis* discussed in Chapter 2, I explored some of Bregman's ideas about what information is conveyed by sound to frame the problem of making a large spatial sound design for a virtual 3D environment.

A short lexicon of auditory diagrams

By way of further comparison, it is interesting to examine a series of diagrams proposed by various researchers to explain acoustic space and/or auditory spatial concepts. Some of these are focused on urban environments, some on generalised environments not specific to one location or typology, while others are specific to an application such as electroacoustic sound design for concerts or theatre.

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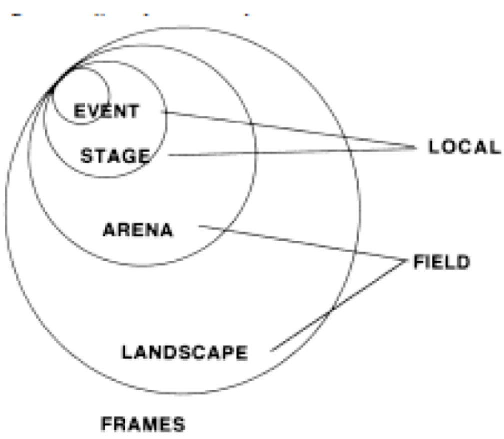
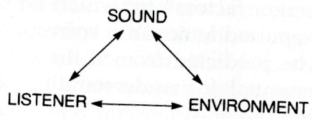
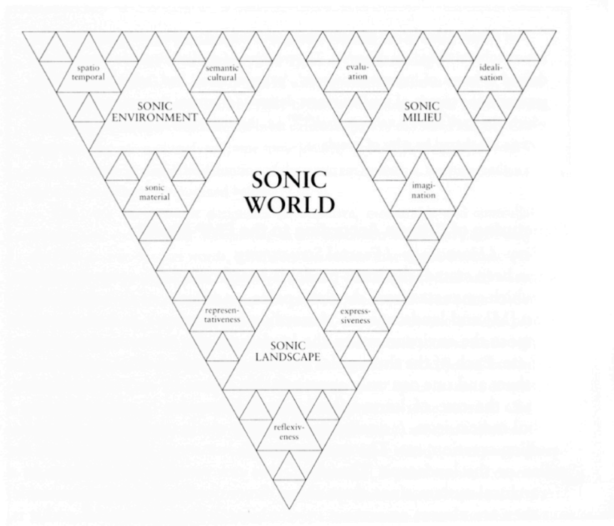
[17] For a general introduction to Bull's work see < http://news.bbc.co.uk/2/hi/technology/3542391.stm>, viewed 1 July 2008, or for a more extensive discussion see Bull (2008).



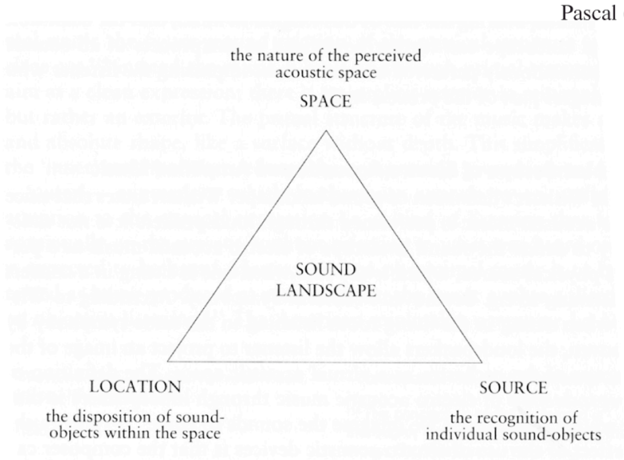
Soundfield frames (Emmerson 1999, p. 139)



Mediating relationship of listener to environment through sound (Truax 2001, p.12)



Synthesised Model of the Sonic World, Amphoux & Pascal (Hellström 2003 p.164)



Characteristic of sound landscape, Trevor Wishart. Diagram by Björn Hellström (Hellstrom 2003, p. 64)

Figure 2: A lexicon of diagrams for acoustic space and auditory spatial concepts

Such schematics as these are highly valuable for interdisciplinary collaboration with designers, for whom the diagram is an essential communication tool. The schematics by Emmerson and Amphoux are characterised by 'nested' components. The scaling of elements in the Amphoux example shows a difference in relative importance or weight of components, whereas in the Emmerson representation, the scaling is one of physical spatial area. The geometric models by Wishart and Truax differ in that a listener is implicit in the Wishart view, while in the Truax a listener is explicitly part of the triangular arrangement. In fact, of the four models, it is only the Truax model that unequivocally positions a listener in the schematic. All models contain an element called "landscape or environment", recognising the importance of locating spatial experience of sound in contemporary acoustic environment research.

Acoustic environment research provides a wider context to electroacoustic practitioners who are motivated to engage with other design disciplines and the broader community beyond the domain of arts practice. The various examples of acoustic environment research are characterised by an interdisciplinary approach as the acoustic conditions of an environment are shaped by a confluence of social, design, technological and cultural factors.

While Western civilisation has achieved sophisticated technological innovations for travel, communication, the provision of shelter and basic physical necessities, the solutions do not always translate into sustaining healthy relationships with environment. The acoustic environment shares the 'out-of-balance' relationships that humans have with other environmental conditions. As a counterbalance to the focus of research on humans in the built environment, I included the work of Steven Feld to exemplify the extent to which human auditory spatial awareness might construct sophisticated relationships with the acoustic environment. The significance of acoustic environment research is that it has brought into human consciousness, a facet of the human-environment relationship progressively degraded by the technological sophistication of industrialisation, and asks how those relationships could be mediated by intervention, whether technological, built, cultural, legislative or educative. Somewhat ironically though, it is electroacoustic technology on which acoustic environment researchers have relied to formalise and extend their work. To that end, I will now examine spatial concepts arising from another application of these technologies, this time to composition and performance of electroacoustic music.

1.2 Spatiality in electroacoustic music practice and theory

In considering the spatial aspects and theories that have arisen from within electroacoustic music, I will concentrate on two historical periods. The first spans the initial twenty-five years of the field from 1950 to 1975. In parallel to research that established the concepts of acoustic environment discussed above was the application of electroacoustic technologies for artistic ends in an expanding network of studios in Europe, the U.S, South America and Asia. The second period covers developments from the 1990s to the present, and has been marked by an expanding array of technologies and techniques for practicing spatial music and sound designs that has implications for institutional studios, which I address in Chapter 6.

Early electroacoustic spatial compositions – 1950 to 1975

Electroacoustic music is an artform able to celebrate the anniversary of its invention, or entrance in the cultural life of Western art practice. On the 5th of October 1948, Pierre Shaeffer, a researcher at the *Radiodiffusion-Television Francaises* (RTF) in Paris, presented a broadcast of *musique concrète*. The program included works based on recordings of steam locomotives in a Paris depot[18], improvised piano and orchestra sounds. On the 18th of March 1950, at the *Ecole Normale de Musique* in Paris, Shaeffer directed the first public performance of *musique concrète* using a five channel sound system, several turntables, and mixers. The loudspeakers were arranged placing two in front on the left and right of the audience, a single speaker at the rear of the audience, and one positioned in the ceiling. Four channels of sound were sent directly to these loudspeakers, while a fifth could be positioned in any of the four loudspeakers during the performance using a device called the *potentiomètre d'espace* (Harrison 1999, p. 118). The link between electroacoustic music and sound spatialisation was established from this inaugural public performance.

The investigation of spatiality in electroacoustic music is enabled by the mobility of its primary technology. Loudspeakers, or point sources, can be organised in a very large number of configurations and arrangements. These actual source points, then become a determining frame for the virtual, or phantom sources and auditory source points of a spatial sound design. Shaeffer's tetrahedral speaker configuration might be seen as a declaration to the field that thinking in three spatial dimensions as a compositional parameter would be a central concern of this new artform. It would not just be the materials of electroacoustic music, drawn from the sounds of the surrounding world, but their spatial design and interpretation would also differentiate this auditory artform from instrumental composition and performance. To achieve similar three-dimensional configurations required performers to be placed around a concert, or opera theatre. In practice, this occurred in a handful of works, no doubt due to the difficulty of finding a suitable architecture and the problems of maintaining the timing of players for a conductor over distances greater than ten metres (Tanaka, 2000). However, in the same period that composers were experimenting with spatial placement of loudspeakers, several works appeared for spatially distributed musicians, notably, *Gruppen fur Drei Orchester* (1955 - 57) by Stockhausen, *Terretektorh* for orchestra distributed through an audience (1965 - 66) and *Persephassa* (1969) for six percussionists by Xenakis, and Kazimierz Serocki's *Continuum* (1965 - 66) for six percussionists. Maria Anna Harley (Harley 1999) discusses these works and other composition and perceptual issues around spatialised instrumental music.

The twenty years from Shaeffer's concert in 1950 saw the rapid development of new strands of electroacoustic music, electronic music and computer music. The spatial presentation

18 In a lecture on electronic music since the 1960s (August 7, 2007, University of Melbourne) Tristram Carey commented that making a location recording of a train in 1958 was difficult. Recording equipment was cumbersome, and one had to convince authorities to allow the recording to occur as a staged event to ensure a suitable recording was made.

of works became a feature of the artform with large-scale projects being presented as part of the international series of World Fairs or Expos in this same period. Of the ten international Expos held between 1951 and 1975, three included purpose-built structures for spatial electoroacoustic works by leading composers. These were the Expos in Brussels (1958), Montreal (1967) and Osaka (1970). The project for the Philips Pavilion is extensively documented in Marc Treib's *Space Calculated in Seconds* (Treib 1996) where he describes the collaborative process, architectural and construction issues, as well as the production and presentation of two new electroacoustic works presented over hundreds of loudspeakers attached to the curved surfaces of the Pavilion. Varese's *Poeme électronique* and Xenakis' *Concret PH* were presented almost daily in twelve sessions. In 1967, several countries presented spatial electroacoustic works in their national pavilions. Iannis Xenakis again represented France with the work *Polytope* that was scored for four identical instrumental ensembles placed around a centrally located audience, but presented over multiple loudspeakers and accompanied by twelve hundred flash bulbs triggered by a control tape attached to a network of intersecting steel cables outlining curved geometrical shapes (Harley 2002). The 1970 Expo in Osaka saw three composers present works on a large scale. The West German Pavilion was an impressive dome constructed for the performance of works by Karlheinz Stockhausen; Xenakis composed *Hibiki-Hana-Ma* for the Japanese Steel Federation Pavilion, and David Tudor's performed installation *Rainforest* was presented as part of Experiments in Art and Technology (E.A.T.) in the Pepsi Pavilion's immersive dome.

Over the period 1948 to 1970, an international network of studios appeared, with at least thirty studios being established across all parts of Europe, Asia, North and South America. They were situated in state-funded institutions such as radio broadcast stations or universities, or as part of the emerging electronic and communication research industry complex. Some were established purely for experimentation with a production focus while others also included what would now be considered research programs. The first studio to open in 1948 was the Club d'Essai in Radio France which became the Group de Recherches Musicales in 1951, and was closely followed by the Columbia Electronic *Music Centre* in New York (1952) and the WDR Studio in Cologne (1953). In the twenty years from 1950, a total of thirteen studios opened across Europe; five in Canada and South America, four in the U.S; two in Germany and France, and one in Japan (Clozier 1998, p. 191). These institutional studios remained the primary places of making electroacoustic works until the 1980s when technological advances – mainly in computing, musical instrument design and connectivity – meant individual practitioners could establish home studios for part or all of the process of making work.

Concepts of spatial composition from 1950

The primary texts of spatial sound knowledge from the 1950s to the 1970s are the works themselves. This includes both score-based instrumental compositions and electroacoustic works on multi-channel tape. In her PhD thesis and a suite of papers analysing spatial instrumental compositions from the 1950s, Maria Anna Harley has provided substantial analytical texts and categorical distinctions. For her, the term *spatial* relates:

> … to the physical, three-dimensional space, or its enclosed fragments within which the music is performed, and not to the abstract realm of pitch space or its derivatives. The transformation 'point to sphere' refers, then, to the changing understanding of music from the purely temporal non-spatial to the fully spatio-temporal (Harley 1993, p. 124).

The image of the point for Harley is the start of a conceptual trajectory. The point has no volume, is bodiless and the spatial aspects of musical composition and performance are irrelevant. On the other hand, the sphere provides a conception for a music that is perceived in the "entirety of its spatio-temporal presence surrounding the listeners with a multi-directional pattern of sounds" (Harley 1993, p.124). Her study sets out to define spatialisation and classify spatial scenarios, particularly through three aspects of spatialisation in post-1950s instrumental music: " (1) the expression or simulation of spatial images and forms (i.e geometric patterns) in music, (2) the movement of sound, (3) the symbolic function of spatialisation" (Harley 1993, p. 124). Her final definition of spatialised music is:

> … music with a quasi-spatial structure defined by the composer in the score or in another medium of sound coding (digital or analogue recording, specific software). This quasi-spatial structure can assume different forms, including ensemble dispersion specified in the score, the movement of sounds, performers and the audience, and the juxtaposition and interaction of real and virtual sound sources. The presence of the technique of spatialisation can be recognized in every situation in which the position (direction and distance) of the sound sources and the acoustic quality of the performance space are given compositional importance (Harley 1993, p. 128).

Exemplars of spatial thinking and approaches from this period are diverse, and in some instances now appear to be more theoretical construct than actually perceptible. Harley focuses on a mix of instrumental and electroacoustic composers including Henry Brandt, Pierre Boulez, Luciano Berio, John Cage, Elliott Carter, John Chowning, Francis Dhomont, Brian Ferneyhough, Peter Maxwell Davies, Bruno Maderna, R. Murray Schafer, Karlheinz Stockhausen and Iannis Xenakis. In her analysis, Harley focuses on the three aspects of spatialisation quoted above. In a later paper on spatial sound composition, Harley outlines a thesis that composers have in some instances unwittingly followed principles of Albert Bregman's auditory stream analysis theories in constructing their works (Harley 1999, p. 148). This paper provides examples from the composers' works listed immediately above in sections entitled: "spatial distance and stream segregation", "spatial movement and streaming effects", "the serialisation of direction", "spatiality and the stage", "geometric sound shapes", "sound masses and fusion" (Harley 1999). She notes in the conclusion that there seems to be general agreement that spatial segregation of performers or loudspeakers helps to clarify musical textures, which works best in conjunction with effects of "pitch-timbre-dynamics-timing" (Harley 1999, p. 165).

In the electroacoustic realm, notable developments immediately after the period 1950 - 1970 include the first speaker orchestra concerts by the Groupe de Musique Experimentale de Bourges (GMEB) in 1973 and the Groupe de Recherches Musicales in 1974. Both these systems were based around multiple speaker set-ups for sound diffusion or speaker orchestra. A composition is made in stereo format, then mixed to many loudspeakers via a modified mixing-desk or other system, that splits these two-channels across many. For an English description of these systems, Harrison gives an account of the Birmingham Electroacoustic Sound Theatre (BEAST) system, including several configurations as a practical guide to diffusion over many channels (Harrison 2000). There are several advantages to sound diffusion from a stereo format. Studios can be equipped with commercial technologies developed for the predominately stereo formats of recording and broadcast. Studio configuration is simpler, not requiring multiple loudspeakers and more complicated cabling patching or routing systems. Works can be easily translated between two different speaker orchestras, even if those systems contain more or less loudspeakers than the original, that is; the work can be 'scaled' to a different number and spatial layout of loudspeakers. The work might also be released on commercial CD or broadcast without the requirement of additional remixing.

Commercial systems and the public domain

Except in the case of the Expo projects, the audience for concert presentations by electroacoustic studios was small compared to other forms of music-making, or for other contemporary media such as film. The use of multi-channel audio in commercial film dates back to 1938 - 41, when the Disney film studios produced *Fantasound.* This sound spatialisation system, originally developed for the film *Fantasia* (1940), included three channels of recorded sound played back over three front channels and two rear channels, closely resembling Tomlinson Holmans' 1975 development for the film *Star Wars* (1977) (Malham and Myatt 1995, p. 59; Holman 2000, pp. 12-13, cited in Ekeberg 2002, p. 85). Originally named THX (Tomlinson Holman Experience) the now renowned 5.1 system has moved beyond commercial cinemas, and is available to domestic users for music, film and computer games. A critical difference of spatial sound systems with screen is the place-direction of audience attention. The screen is a frame for the area film makers refer to as "story space", anything that occurs outside of this frame, an off screen sound for example, is potentially disruptive to the flow of the narrative taking place through the screen.

Contemporary state of spatialisation

Spatialisation is a term that encompasses a number of perceptually distinct effects. Systems are created to implement effects such as reverberation or sound movement either singularly or in parallel usually with the purpose of simulating how sound performs in the physical world. The main hardware and software components of any system must be compatible and closely integrated to work. This is not a trivial requirement, and one that is sometimes difficult to achieve. Spatial audio systems can generally be grouped into two types, that I will call 'fully integrated' and 'component' systems. The first defines systems that have hardware and software from the same manufacturer while the second integrates hardware and software from several manufacturers. While systems in the first group tend to be more expensive than those in the second, they are more stable. Systems in the second group are stable to the degree that all suppliers have properly implemented industry standards and protocols, and incompatibility issues have been resolved. Both types of systems generally have the following components: large storage media, software to access the audio from the storage media, software to control output routing or matrix-mixing and panning across the loudspeakers of the system (which could number from four to over one hundred), and digital to analogue conversion hardware.

Roads (1996, p. 453-454) provides a brief list of sound spatialisation systems developed between 1977 and 1990. Each of theses systems was developed mainly for experimental applications by European composers working in concert venues on at least eight loudspeakers but often on sixteen or more. In the period from 1990 to 2007, several notable research and commercial systems have become available that conform to the description of a fully integrated system discussed above. Two examples are the *Matrix 3* system from Meyer Sound[19] and the *Audio Box* from Richmond Audio.[20] Both are targeted to live theatre use and theme parks. The systems include both hardware and control software with graphic user interfaces for track selection, playback spatialisation and other processing. Other systems for synthesising 3D acoustic space include the DIVA Auralization[21] system and the Lake Huron, which is suitable mainly for acoustic simulation and engineering applications. This latter system implements a real-time convolution method, whereby a listener can experience a simulation of a design before it is constructed. An acoustic model is made in an auralisation package such as CATT or ODEON, and convolved with sounds in real-time in the Lake over headphones or multiple loudspeakers. The process would appear to be most successful for large, critical listening projects such as concert halls, churches and public address systems in railway stations.

Microphone techniques and technologies have been developed in recent years, to ensure that the spatial qualities of a sound field are captured in audio recordings. The least number of channels required for doing so is two, with different configurations ranging from spread microphones, to 'dummy-head' systems using small microphones mounted in the ears of an actual dummy head, to microphone array and ambisonic systems. Each system requires specialist production techniques to decode and remaster the recording, which is then suitable for either headphone, stereo or multi-speaker presentation.

Since the mid 1990s the cost of establishing a home spatial sound studio has considerably diminished. Advances in quality and cost reductions in the primary components needed for a system have been the main drivers for this change. Multi-channel sound cards are

19 See <http://www.meyersound.com/lcs/matrix3/>, viewed February 15, 2007.

20 See <http://www.richmondsounddesign.com/>, viewed February 15, 2007. This system was developed from the DM-8 multi-DSP box, designed by Vancouver engineer Tim Bartoo, and closely associated with Barry Truax's studio at Simon Fraser University, see http://www.sfu.ca/~truax/dm8.html, viewed February 15, 2007.

21 See http://www.tml.tkk.fi/Research/DIVA/past/acoustics.html#RESULTS, viewed February 25, 2007.

now available from AUD$1000, and reasonable quality loudspeakers can be purchased to create the array of source points needed for spatial audio. Even laptop computers now possess enough hard-disk storage and CPU power for a single user to produce large projects, undertaking all major production tasks using commercial and freeware suites of software for sound recording, processing, compilation and production.

Spatial sound industry magazines are a useful source of information for home, project, research and commercial studio users[22], while professional and academic communities associated with spatial audio meet in forums such as the International Community for Auditory Display (ICAD), and special meetings of the Audio Engineering Society (AES) dedicated to surround sound. ICAD is a broad group of researchers, whose focus in on:

> … the use of sound to display data, monitor systems, and provide enhanced user interfaces for computers and virtual reality systems. It is unique in its singular focus on auditory displays and the array of perception, technology, and application areas that this encompasses.[23]

The 19th and 24th conferences of the international AES, along with the 28th meeting in Pitea, Sweden in 2006, have been dedicated to surround sound. The AES community mounts an annual conference with up to eight themed areas for research papers. Other AES conferences such as the 16th at Helsinki University of Technology, included session titles such as the Perception of Spatial Sound, Spatial Sound Reproduction and Applications, Psychoacoustics and Binaural Auditory Models, Binaural Technology: Theory and Implementation, Multichannel Audio: Theory and Implementation, Subjective Evaluation and Listening Conditions for Spatial Sound.[24] Other meetings such as the CREATE Symposium (2000), *Sound in Space*[25] were convened to discuss and present research into compositional, aesthetic and technical aspects of spatial sound practice.

One implication of this technological and knowledge development has been the rise of spatial sound projects at the scale of architectural space. Specifically, permanent sound installations as opposed to temporary arts-based ones. Commercial companies offering design services that essentially make auditory space have emerged. Composer and sound designer Louis Dandrel founded the Paris based company *Diasonic* offering services from sound studies to "creating, restoring or improving an object or a place's 'voice' by working with sound as a material". [26] Dendrel's company has completed projects for the Paris Railway, the Cité de la Musique, and an audio clock in Lille. *Resonant Designs*, a Melbourne based company, has worked closely with architectural firms on new cultural sites, zoos, museums, aquariums, visitor centres, urban and commercial projects.[27] Nigel Frayne, the Director of *Resonant Designs*, gives the following account of his practice framed within his work for LAB Architecture

22 See <www.surroundpro.com/> and <http://www.ambisonic.net/>, viewed February 25, 2007.
23 See ICAD website at <http://www.icad.org/websiteV2.0/Community/description.html>, viewed February 25, 2007.
24 See <http://www.acoustics.hut.fi/aes16/papers>, viewed February 25, 2007.
25 See <http://www.ccmrc.ucsb.edu/news/space.html>, viewed February 25, 2007.
26 See break out box, far left at <http://www.diasonicdesign.com/site/services/index.html>, viewed February 25, 2007.
27 See <http://www.resonantdesigns.com/>, viewed February 25, 2007.

Studios' Federation Square project in Melbourne, Australia. His initial response is to a question from Sabine Breitsameter to describe the difference between a 'sound designer' and an 'acoustic designer':

> For example, a person who constructs the sound from nothing, which is effectively a sounding object, they fictively design sound as they would design a chair. Aperson who creates a sound for a film in the cinema, creates a sound design. The work that I was doing in museums was designing sound, however, in the way sound performs in a space. For my own consciousness of what I do, I prefer to have a definition which is more succinct and is less open to interpretation. When I say, 'I am an acoustic designer', people will understand what I mean and I don't need continuously to explain all the different activities I undertake (Breitsameter 2005, para. 1).

Later in the interview, Frayne is asked about his specific role in LAB Architecture Studios' Federation Square project in Melbourne, and his acoustic design inside the complex for the Australian Centre for the Moving Image (ACMI)[28]:

> It's a very fascinating building with quite unique architectural features, and the notion [in my design] is that it should have an acoustic response. The acoustic should not just be the rumble of the air conditioning, the escalators, footsteps and sounds bouncing off the reflective surfaces. We can be more creative about that and actually create some content or some fidelity for the ear for the people as they move through.
>
> This assists not just to create an aesthetic, but also it creates a sense of different zones within the building where people will pass through. When they stand in the atrium, it's very large, it's very glossy, and there is lots of light through the glass. It's a certain type of ambience. When one stands there, one should feel quite different to when one is in a corridor, which is a completely different type of ambience (Breitsameter 2005, para. 10).

As with Dendrel's notion of voice, Frayne's approach is strongly experiential where sound is considered a *material* on which design decisions may be enacted. While the acoustic conditions of architectural spaces are on the whole unintended consequences of geometry, surface materials, and the presence or absence of noise sources, acoustic designers seek to create particular auditory experiences in listeners. The critical distinction between temporary arts-based installations and acoustic designs within architectural spaces is that of cultural presence. Projects that remain in architectural spaces allow a continued engagement by listeners. Removed from their usual performative role in compositions, designed sounds become part of a daily existance in urban space allowing a renegotiation of spatial experience through an enriched auditory field.

28 For a history of the site, architecture and design of Federation Square, see <http://www.federationsquare.com.au/index.cfm?pageID=26>, viewed June 20, 2007.

A further intersection of electroacoustic music and architecture is exemplified in a sound installation for Renzo Piano's Auditorium Parco Della Musica in Rome in 2002. Although the project was realised during the opening of the Auditorium, the process of collaboration and technical implementation is well described in Giomi et al. (2003). The installation was used to play seminal works in the electroacoustic repertoire (Giomi et al. 2003, p. 158), and was intended to be a new instrument for which these pieces could be transcribed, as conceived by Italian composer Luciano Berio (Giomi et al. 2003, p. 157).

At the scale of the urban environment, companies such as the Massachusetts based Harris Miller Miller &Hanson Inc. (HMMH) offer services to provide clients a sense of the way a planned space will sound. They use binaural recordings, measurements and acoustic analysis to build virtual soundscape scenarios. The idea, although simple, is compelling for its interchangeability of contexts, sources and environment.[29] This use of sound as its own best representation is a theme I discuss further in the *CitySounds* project. Other projects appropriate existing WiFi nodes and WiFi-enabled technologies to create sound environments. The *Tactical Sound Garden* project of Mark Shepard and team, is described as:

> An open source software platform for cultivating public 'sound gardens' within contemporary cities. It draws on the culture of urban community gardening to posit a participatory environment where new spatial practices for social interaction within technologically mediated environments can be explored and evaluated. Addressing the impact of mobile audio devices like the iPod, the project examines gradations of privacy and publicity within contemporary public space.[30]

Commercially available technologies for sophisticated sound spatialisation are now available and affordable for professional research and applications, teaching and learning, home use, performance and cinema theatres and public spaces. These enabling platforms have in part supported the emergence of commercial sound and acoustic design companies. While the technological solutions have expanded, producing large-scale projects as discussed above remains a critical task. I use "scale" to indicate duration of the finished work greater than an extended concert work of approximately thirty minutes; number of loudspeakers and spatial dimensions of the speaker system. Another aspect of scale is a work that is itself a continuous duration in the space of presentation, as opposed to a series of sound effects that might occur in a theatre show. The specificity of most large-scale systems means that prototyping in an off-site studio is also a difficult challenge. Constructing software solutions and sound design approaches to resolve such problems was the aim of my own projects, particularly *Canopies* for an urban soundscape system and the spatial sound designs for the virtual reality works *Symbiosis* and *Ecstasis*. A theme that will be expanded upon at the conclusion of this thesis is a role for institutional electroacoustic studios to support spatial sound design practice not just at a technological level, but to engender a greater auditory spatial awareness in designers and the general public through its research, teaching and cultural endeavours.

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29 See audio example at <http://www.hmmh.com/soundscape_01vs.html>, viewed February 25, 2007.
30 See <http://www.tacticalsoundgarden.net/#>, viewed February 25, 2007.

1.3 Toward the design of acoustic space

Making and maintaining spatial concepts

> *... It is important to understand that relativistic space is* not *some 'transcendent' reality in the mind of some God. In a very powerful sense it would not exist without Einstein and the subsequent community of relativity physicists ... Just as soul-space disappeared with the demise of the community who supported that concept, so too relativistic space would disappear from the human psychic landscape without the continued sustenance of the physics community (Wertheim 2000, p. 306. Quotes and italics in original).*

Wertheim's observation that a spatial concept's continued sustenance is contingent on a community also implies that community's shared responsibility to keep that spatial idea on: "the human psychic landscape". It should be in no way insinuated that auditory experience exists only because a professional community trains an intellectual spotlight on the acoustic environment. Rather, I would suggest that the sound-based researchers are working at a time in the emergence of an acoustic space, which Wertheim might be describing when she says:

> I believe it is that our spatial schemes are not only culturally contingent, they are also historically contingent. There is no such thing as an ultimate or supreme vision of space; there is only ever an open-ended process in which we may constantly discover new aspects of this endlessly fascinating phenomenon. Throughout history new kinds of space have come into being, as older ones have disappeared (Wertheim 2000, p. 307).

Wertheim further asserts that:

> … the production of space – any kind of space – is necessarily a communal activity. The spaces that we inhabit are irrevocably articulated by communities of people, who cannot express their ideas about reality except through the medium of language. How we see ourselves embedded in a wider spatial scheme is not simply a question of getting to know the 'facts'; it is always and ever a matter for social and linguisitic negotiation (Wertheim 2000, p. 306).

Much of the work to date in acoustic ecology has been in establishing the facts of the field. To that end, the work of CRESSON and the WSP has been critical to establishing the grounds for a common language of experiential moments in the soundscape. Wertheim also notes that Einstein himself recognised that it is the language we use – the concepts that we articulate and hence the questions we ask – that determines the kind of space that we are able to see (Wertheim 2000, p. 306), and of course, to hear. However, for the field of acoustic environment research to evolve, and for the acoustic spaces to be rendered, the role of design will be to provide answers to those questions and to play a critical role in the social and linguistic negotiation for new acoustic spaces.

Auditory spatial awareness

One of the most recent and compelling terms to enter sound studies is Barry Blesser's concept of auditory spatial awareness. Blesser's work over forty years in digital audio research included the establishment of the Lexicon digital audio company in 1971, and his invention of the first commercial reverberation system in 1976.[31] His landmark study *Spaces Speak, Are You Listening? Experiencing Aural Architecture* (Blesser 2007) develops many of the themes from his earlier Audio Engineering Society paper *An Interdisciplinary Synthesis of Reverberation Viewpoints* (Blesser 2001). In this paper, he introduces the concept of an auditory spatial awareness:

> While the physics and statistics of acoustic spaces are reasonably well understood, and while their musical implications have a large amount of supporting literature, studies on auditory spatial awareness are remarkably sparse. Perceptual models and cognitive theories are explicit parts of most psychological disciplines, such as language ability, pattern recognition, memory duration, and skill learning, but they are not yet strongly represented in auditory space perception (Blesser 2001, p. 867).

Blesser notes that three disciplines share an interest in understanding "reverberation", the closest word that indicates an "auditory manifestation of the enclosure" (Blesser 2001, p. 868). These include audio engineers, acoustical architects and music composers, particularly when collaborating within auditory-based arts, and I would add, auditory-based communication, for example, in radio broadcast or places reliant on acoustic communication. After describing the three components into which the human auditory system decomposes sound events[32], Blesser goes onto to observe that:

> Of the three components, auditory spatial awareness has received very little scientific attention. It is viewed as a primitive neurological subsystem that contributes to the visual spatial map (Stein and Meredith, 1993). However, it rises to a high level of prominence in the musical arts, and it plays a central part in the lives of the visually impaired. It is underappreciated and underutilized (Blesser 2001, p. 868).

The relevance of the definitive term *auditory spatial awareness* to this PhD study is its reference to the two domains in which Blesser notes auditory spatial awareness has achieved prominence – the musical arts and the lives of visually impaired people. In Chapters 2 to 4, I will discuss sound design projects in arts-based contexts, and in Chapter 5, a project exploring ways the sightless use sound to negotiate space. Blesser writes from a professional background

31 See <http://www.blesser.net/>, viewed February 14, 2007.
32 These are: identity of source, its spatial location, and a visual image of the space within which the source and listener are embedded (Blesser 2001, p. 868).

as an acoustical engineer developing artificial reverberation software. His 'interdisciplinary synthesis' of viewpoints has close relatives in other fields. For example, substantial parts of the discussion later in Chapter 2, arise from my application of electroacoustic music practice to sound design, which Blesser notes is making advances in applied uses of auditory spatial awareness. Blesser outlines more of Stein and Meredith's research findings when discussing "professional bias", which also has profound implications for sound-based practitioners working in expanded milieux and especially when collaborating with visual-based practitioners:

> The preoccupation with the auditory sense modality is a professional bias of those interested in reverberation. However, the human is a fully integrated organism that does not separate sensory inputs, especially vision and sound. Recent results from neurological studies have identified structures in the deep superior colliculus, which historically had been considered the visual map of the world, that also integrate a corresponding audio map [Stein and Meredith 1993]. These auditory neurons are binaural and respond to spatially located transients. At this level, the senses are amodal to support perceptual cohesiveness for stimuli that exist in multiple senses at the same time and place. Cooperating modalities provide a redundant source of information about the external world and provide the organism with an evolutionary survival advantage. Each modality, tuned to different forms of energy, contributes to the whole, which is bigger than the sum of the parts (Blesser 2001, p. 887)

The idea of each modality tuned to different forms of energy is a compelling one. The concept of tuned modalities suggests interconnectedness without privileging one sense over another. Yet it also provides a demarcation, which should make imperative a balance between at least the visual and aural materials in any collaborative endeavour. The amodal nature of neurons and their role in establishing perceptual cohesiveness in one way settles any debate on the need to give equal attention to visual and aural design components. Our sensory-perceptual systems are made to cooperate. Stein and Meredith specifically name four qualities of a stimulus that are easily translated between modalities. They are: "intensity", "form", "number" and "duration" (Stein and Meredith 1993, p.10). It would seem that ignoring the auditory dimension in design endeavours diminishes human experience, which Blesser suggests can be counterbalanced by awareness, firstly, of the listener's own sound receptors (ears) relative to their physical body, and then, of their body to external spatial references.

> Psychoacoustic research generally ignores the spatial awareness component of perception, focusing instead on the sonic event. The models and theories only attempt to describe the other two dimensions: the *where* and the *what.* Each of these becomes an independent stream; one connects to the spatial worldview, the other to the semantic lexicon, speech or music. The cognitive process requires that all sounds exist some place in the internal world picture, the *where*; there is no nonspatial hearing. The auditory event may be located in front of the listener, inside the head, or spread in the environment. However, because the location of the

auditory event is relative to the listener, placing the source location in absolute space requires that the listener also have a sense of his/her ears relative to his/her body, and the body relative to external references (Blesser 2001, p. 885).

The practice of sound designers could be recast in two ways. Initially, through the provision of a rich repertoire of *what* we hear, by means of the creation of cultural artefacts such as electroacoustic compositions, installations, radio works, recordings, concert series; and through collaborative design interventions on the passive architectures of the spaces *where* we listen. In this respect, the work of CRESSON and *Irec* discussed above can be seen as framing such a repertoire, also in combination with built features of the urban environment. To that end, designers must consider how cultural artefacts contribute to the qualities of acoustic space.

Making acoustic space

In the *Handbook for Acoustic Ecology*, soundscape design is defined as:

… a new inter-discipline combining the talents of scientists, social scientists and artists (particularly musicians)…[who attempt]…to discover principles and to develop techniques by which the social, psychological and aesthetic quality of the acoustic environment or soundscape may be improved. Soundscape design may also include the composition of actual environments, and in this respect it is contiguous with contemporary musical composition. To the extent that it attempts to understand individual, community and cultural behaviour, soundscape design takes the broad perspective of a communicational discipline, and touches such other areas as sociology, anthropology, psychology and geography (Truax 1999, entry for *Soundscape Design*).

Closely related to soundscape design is soundscape composition, which is a type of electroacoustic composition where sounds from and about a specific context, usually a specific place, are the primary material for the work. The sense of the "original context and associations of the material play a significant role in [Design's] creation and reception" (Truax 1999, entry for *Soundscape Design*). Soundscape composition is "context embedded, and even though it may incorporate seemingly abstract material from time to time, the piece never loses sight of what it is `about'."[33]

The difference can also lie in scale of endeavour. The composer of a soundscape composition is concerned with the creation of a work usually for concert or broadcast presentation and limited duration, generally between a few minutes and one hour. The soundscape designer, meanwhile is usually occupied by integration of a complex weave of relationships to create an aural experience in an everyday environment. The *Australian Sound Design Project*, directed by composer and sound designer Dr. Ros Bandt, is a notable resource of practice in Australia, containing details of over one hundred and twenty artists and designers

33 Entry for soundscape composition at <http://www.mti.dmu.ac.uk/EARS/>, viewed February 25, 2007.

and almost one hundred and forty projects.[34] The two types of endeavour might be two realisations of a larger project when, for example, a soundscape design is the basis of a soundscape composition, or a soundscape research project is later 'applied' in a soundscape composition. To illustrate, I will draw on two examples from my own practice discussed in later chapters. Material from the first manifestation of the soundscape design *Canopies: chimerical acoustic environments* was later re-worked for the concert version. In the case of *SoundSites*, the eight-month process of interviews, workshops and research became an exhibition of small soundscape compositions based on the findings and observations of the preceding research phase. Steven Feld's notion of soundscape composition as ethnographic document (Drever 2002) also underpins what I would call the "communicative advantage sound" as its own best representation where Feld states that:

> Soundscape research really should be presented in the form of a musical composition. That is the one way to bend the loop back so that research and the artistry come together and we can auditorally cross those rivers and those creeks and climb those trees and walk those paths without the academic literalism, the print mediation [implies] (Drever 2002, p. 26).

Feld is referring to the potential of a soundscape composition bringing us into the auditory world of the Kaluli and listening to the tribal and environmental interactions conducted through sound-making. The community is literally 'sung-together'. The intention of the soundscape composition is to focus our own auditory attention on a society that creates acoustic space through communal activity. Truax takes the notion to a formal level, when he categorises an acoustic community as "any soundscape in which acoustic information plays a pervasive role in the lives of the inhabitants (no matter how the commonality of such people is understood)" (Truax 2001, p. 66). Central to Truax's model is the way that the acoustic environment creates interpretable differences; hence information and the listener's cognitive processes assign meaning to these patterns through processes such as causality, association, decoding, metaphorical similarity and symbolism.

The idea of communal activity as a necessary condition of space-making is a collective theme in the work of Wertheim, Feld and Truax. Although Wertheim is discussing how languages, and in particular codes and protocols for communication, have been necessary for the construction of cyberspace, it is a communal set of exchanges to which she is referring, without which cyberspace would never have been possible:

> There is here an important lesson that I believe we can learn from cyberspace: Any community that shares a 'world' is necessarily bound into a *network of responsibility*. Without the continuing support of a community, *any* world (that is, any space of being) will begin to fall apart. If cyberspace teaches us anything, it is that the worlds we conceive (the spaces we 'inhabit') are communal projects requiring ongoing communal responsibility (Wertheim 2000, p. 304).

34 See <www.sounddesign.unimelb.edu.au/>

In Chapter 6, I will return to the critical role that a sound studio cast as a community of practice can play in actualising an acoustic 'space of being' and its role in the production of spatial schemes, as Wertheim describes here:

> But a people who conceive of space in purely physical terms are virtually compelled to see themselves as purely physical beings. This, of course, is not the only choice; people in non-Western cultures have conceived entirely different options. What *is* universal is that conceptions of space and conceptions of self mirror one another. In a very real sense, we are the productions of our spatial schemes (Wertheim 2000, p. 308).

The recurring theme is that spatial schemes are dynamic, we must continually attend to their presence or they decay. Where arts-based sound practitioners tend to produce *events* that might investigate or propose spatial schemes, it is the project of design to make spatial schemes enduring, to bring them closer to the quotidian world of listeners. Within architectural practice, investigation into new spatial schemes is being pursued mostly through digital design which itself is proving a new collaborative field for visual-aural research and production. Although in *The Production of Space* Lefebrve discusses listening and sound in only a few instances, he provides the following description for the role of hearing in lateralisation of the body in space. This quote is preceded by a discussion on requirement that pairs of determinants be used to indicate left, right or up and down:

> According to Tomatis, the hearing plays a decisive role in the lateralization of perceived space. Space is listened for, in fact, as much as seen, and heard before it comes into view. The perceptions of one ear differ from those of the other. This difference puts the child on alert, and lends volume and physical density to the messages it receives. The hearing thus plays a mediating role between the spatial body and the localization of bodies outside it. The organic space of the ear, which is brought into being through the child's relationship with its mother, is thus extended to sounds from beyond the sphere of that relationship – to other people's voices, for example. Hearing-disturbances, likewise, are accompanied by disturbances in lateralization in the perception of both external and internal space (dyslexias, etc.) (Lefebrve 2003, pp. 199-200).

Re-thinking the role of auditory space – sound influencing other design concepts

As the practice of architecture is enveloped by digital modes of production, analysis and presentation – albeit mostly in the visual domain – of new roles for electroacoustic music in this digital-making are being canvassed, with the potential that such cross-pollination will develop new spatial concepts. For Rebelo and Coyne, the potential lays in the application of tools from time-based media, particularly the Max/MSP/Jitter platform, mainly used by"artists, musicians and programmers who develop applications for audio and video processing, interactive installations and audio-visual performance" (Rebelo & Coyne 2003, p. 4). Although not strictly discussing transference of ideas about auditory space to the visual domain, the authors propose that these tools, developed for and by time-based artists, are a means of enacting the title of their paper, *Resisting the Smooth*, a notion to describe "'distressed space' as part of a design strategy in the context of time-based media", particularly where:

> This shift from space to time is commonly associated with the ideal of smoothing boundaries and developing seamless environments. Contrary to this supposition, we propose that the putative collapse of time and space exposes disjunction and disruption (Rebelo & Coyne 2003, p. 1).

> The play with geometrical parameters in the context of time suggests a mode for interfering in space; in a way that extends how time-based distresses are exploited in cinema, music and performance art. The architectural design distress does not provide a formula for building but introduces experimentation in disruption, which is commonly left behind in computer-aided design (Rebelo & Coyne 2003, p. 5).

In *Revealing the Continuum: An Investigation of Sound and Space*, Talia Dorsey puts forward an argument:

> … for architecture to consider anew its examination of space, and specifically its consideration of the acoustic dimension of architectural space, as a means of approaching the degree of complexity demanded by the cultural condition of our time (Dorsey 2000, para.4).

Dorsey advances her argument through a discussion of electroacoustic music as a disciplinein which "acoustic space and physical space…unfold and refold. The sound/space relationship has been free to extend beyond the one-to-one confines of a sound in a space" (Dorsey 2000, para. 29). The electroacoustic composers she proposers as exemplars in this project are Ryoji Ikeda, François Bayle, Asmus Tietchens and Thomas K_ner.

> The field of electroacoustic music and architecture meet at the plan of the sound/space interface … The sonic field that surrounds, envelopes, and flows within architecture implicitly embeds architectural space with an acoustic dimension (Dorsey 2000, para. 4: *The Return*).

To touch briefly on the notion of architectural space embedded in the acoustic dimension but without digressing into a complete history of architectural acoustics, it is worth noting salient points raised by Sheridan and van Lengen in their paper *Hearing Architecture: Exploring and Designing the Aural Environment*:

> Vitruvius provides much insight into Roman knowledge of acoustics. His writings also serve as a lens through which one can glean an understanding of earlier Greek

> consciousness of sound, music, and architecture. In fact, Vitruvius devoted as much text in *The Ten Books on Architecture* to sound, music, and acoustics as he did to site design, materials, and color—a level of attention unheard of in current architectural writing (Sheridan and van Lengen 2003, p. 38)

Their paper reports on an experimental design studio at the University of Virginia that focussed on the proportional organisation and aural qualities of selected spaces on the University's campus. It would seem that an underlying agenda of the studio was to have students understand how visual thinking in Western culture has shaped building design:

> Historically, there have been close correlations between aural and visual building traditions. However, when oral cultures transformed into literate ones, visual priorities tended to shape architectural form making, thus reducing the primacy of sound-sensitive criteria (Sheridan and van Lengen 2003, p. 37).

In comparing different building typologies on campus, the authors report that students were able to consistently make subjective judgements about the differing aural qualities of rectilinear and curvilinear spaces. The latter exhibited "pronounced areas of sound focus including strong 'whispering gallery' effects that created a disjunction between the visual and acoustic distance between two loudspeakers" (Sheridan and van Lengen 2003, p. 42).

If the emergence of critical cultural awareness of acoustic space, and the simultaneous rise of spatial sound composition are considered as two facets of a new spatial awareness, then the opportunity for a new design discipline founded on both may also be imminent. If the term "design" is taken to mean a process through which relationships between inhabitants and environment are created or transformed, then interventions that bring change between listeners and the acoustic environment enter into the realm of design. To that end, we now see professional distinctions arising such as sound designer, acoustic designer, aural architect or soundscape designer. Common to any of these sub-discipline distinctions is some process to encode, represent and communicate thinking in material form.

Technology, representation and acoustic space

> While an object that is fixed in space, such as an urban landscape, can carry knowledge that can be available to anyone visiting it at any time, a representation of it is necessary if something like the same knowledge is to be transmitted to people in other places. Many products are likely to be widely found, but most of the works of the physical designers considered here are located at particular sites. What must therefore be considered is the ways in which transmission of design knowledge is affected by the use of representational procedures (Downton 2003, p. 118).

Spatial audio systems, electroacoustic sound studios, and spatial composition techniques provide the foundation on which to build new auditory representational methods for professional practitioners. The application of auralisation techniques to large-scale projects is regularly reported in architectural computing literature, audio engineering and acoustical engineering literatures.[35] For these professional applications, representational procedures might render reverberation characteristics of iterative design moves, indicative sound events from similar spatial typologies, post-evaluative soundscape recordings, or speculative sonic events and conditions. In the public domain, cinema audiences now experience virtual sound fields created by similar technologies and techniques. Cinema theatre construction, spatial audio technology and film sound design techniques all combine to make contemporary spatial sound experiences for theatre audiences that approach the aural equivalent of "images with enough literal verisimilitude" as discussed by Wertheim below. We are, as Downton points out:

> … sophisticated consumers of media [who can]… read the scale clues present in the image of a landscape or large building and have an everyday knowledge of the size of items such as a car or a watch. However, seeing the original is experientially and intellectually different from seeing its image; we may never have previously understood that it is a particularly low, wide car or a watch with a ridiculously large face (Downton 2003, p. 119-120).

While in the contemporary world it is electroacoustic technologies that provide representations of resonant acoustic spaces, it was once the domain of cathedral builders to construct the acoustic conditions of another world. Sheridan and van Lengen paint the following image and role for a resonant social, and in this instance, religious experience in previous times:

> … the abbeys and cathedrals that ranged across Europe from Le Thoronet … in southern France to Santa Croce in Florence formed an array of sacred resonators for the airing of the Christian word. They did not bring an orally transmitted mythic past into visual space so much as they created a kind of visual envelope around the core aural experience of the liturgy (Sheridan and van Lengen 2003 p. 39).[36]

An aspect of the urban environment most profoundly degraded by plant and equipment for building services and for transport has been the acoustic horizon, or limit of auditory spatial awareness. Perhaps the proliferation of spatial audio technologies into the home, cinemas, sound installations and vehicles is restorative. In a natural environment, the acoustic horizon might be measured in kilometres. In urban environments, the constant hum collapses the acoustic horizon to just a few metres. The sense that one is embedded in an acoustic field, with the prospect of sharing a communal auditory experience is impossible. The persistence of a single space filling, yet space collapsing sound, nullifies what should be a social

35 For examples, see websites with conference and paper information for the International Congress on Acoustics at <http://www.icacommission.org/, the Acoustical Society of America at <http://asa.aip.org/>, and the Audio Engineering Society at <http://www.aes.org/>.
36 I recall visiting the Cathedral at Chartes, rising out of the surrounding plain like a coral reef, dotted with the low-volumed domestic and commercial buildings of the town. Projecting my auditory imagination back to this time, to hear sound in such a reverberant space, when one's entire aural experience had been one of small domestic rooms, and open spaces must have made an indelible auditory impression.

space scanned by the ear and filled by the sounds of human agency such as voice and footsteps. Such a scenario exists on the main campus of RMIT University, Melbourne and has been studied in soundscape electives I taught during the research discussed in this thesis. The central zone of the city-based campus is surrounded by more than thirteen plant and equipment units for air-conditioning, fume extraction and server room cooling, and are shown in Image 1, below and Sound example 1. The collective effect is a masking of reverberant qualities so the auditory spatial experience of volumetric space is lost. It is as if the space one inhabits has visual depth but no acoustic depth, forming the auditory equivalent of staring at a dirty grey wall a few metres from one's nose.

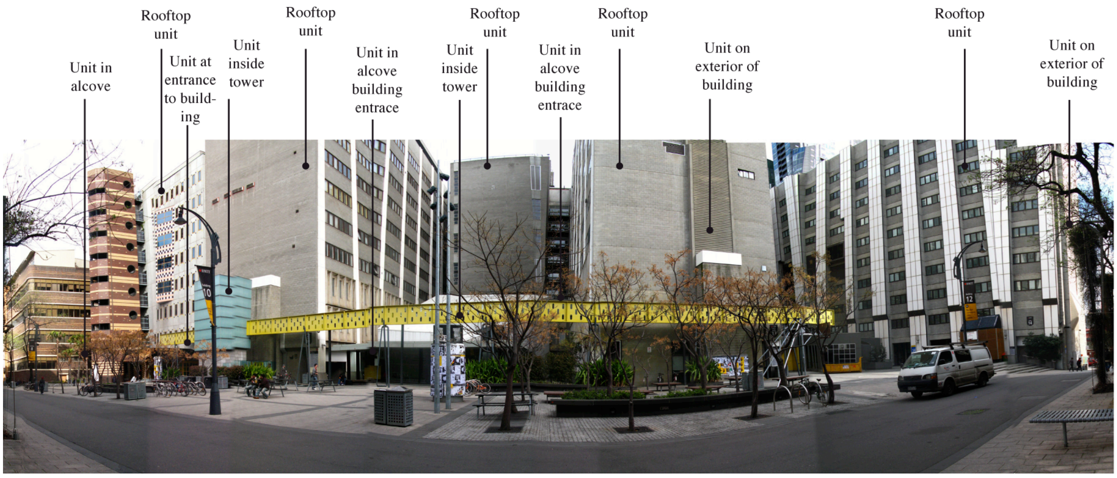

Image 1: Bowen Street, RMIT University with indication of main noise sources

The plant and equipment units shown here stretch along 150 metres of the main University campus. The buildings opposite those depicted (behind the photographer) also have air-conditioning and cooling units for computer server rooms, along with extraction fans for science laboratories. See Sound example 1 for a recording made on site during a student soundscape elective.

Sound example 1: Air-conditioning on Bowen Street, RMIT University

This recording was made during a soundscape elective in 2002. The aim of the elective was to enact change on the acoustic conditions of the campus while students conducted a survey and made perceptual observations and sound pressure level metre readings. In Sound example 1.1 (Air-conditioning-1), footsteps and voices are heavily masked by the sound of air-conditioning outlets as marked in Image 1. In Sound example 1.2 (Air-conditioning-2) the descending glissando of a large unit shutting down can be heard, along with a slight change in the sound spectrum quality of the site.

That which is lost to the listener in these environments can be returned to auditory culture through spatial sound technologies. I believe this is a moment in auditory history akin to the application of geometry to visual representation. Most electroacoustic technologies attempt to maintain spatial integrity, inthe sense that "…all objects appear to reside in one continuous, homogeneous, three-dimensional space." (Wertheim 2000, p. 107). In discussing Roger Bacon (c.1214 – 1294) and his views on geometry, Wertheim quotes Samuel Y. Edgerton:

> For Bacon, the key to the new realistic style of painting was the application of *geometry.* 'Though he probably knew nothing of the relevant artistic activity in far-off Italy at the time,' Bacon '…was well aware of the power of visual communication, and became convinced that image makers … must learn geometry if they were ever going to infuse their spiritual image with enough literal verisimilitude' (Wertheim 2000, pp. 92-93).

In other words, Bacon believed that if artists understood geometry and applied it to their work they could make religious images look so *physically real* that viewers would believe they were "*gazing at the actual events depicted*. He called the new style 'geometric figuring'" (Wertheim 2000, p. 92. Italics are original).

> With almost preternatural foresight Bacon had perceived the psychological power of visual simulation. By the application of geometry to image, he tells us, bodies can become 'sensible' to our eyes (Wertheim 2000, p. 92).

As Wertheim goes onto to explain, Bacon saw the application of geometry to images creating illusions as "so powerful that people would be convinced of the 'reality' of what they were seeing ... Roger Bacon might justifiably be called the first champion of virtual reality." (Wertheim 2000, p. 93).

A prospect for spatial sound design reflects such a notion in the auditory domain. Notwithstanding that the application of technologies for spatial auditory simulation does have practical outcomes for reinstating aural experience into the realm of design, it is the prospect of the "psychological power" (Wertheim 2000, p. 92) of sound; of new sound design techniques and listening contexts that should be the realm of spatial sound design. Where the application of geometry might make images appear physically real, the application of aural geometries in a spatial sound design embeds the audience within an approximation of an acoustic energy field. Whereas the audience gazes into the world visually depicted, they are physically located within the aural depiction. However, the effects of acoustic conditions on our spatial experience are not limited to perception, so I will next consider ways health and social issues intersect with ideas of the soundscape.

Broadening the agenda: health and social aspects of the acoustic environment

The history of noise in Western urban environments closely follows that of mechanisation. Through literary sources[37], Schafer tracks the rise of auditory awareness of

37 The World Soundscape Project sound references in literature, can be found at <http://www.sfu.ca/sonic-studio/index3.html>, viewed February 7, 2007.

noise, brought on by the new factories and transportation systems from the approximate period 1760 to 1900. Schafer notes that street music was often a source of complaint and cites examples from London in the 1860s when professionals – composers, painters, writers and mathematicians, proposed or supported bills of Parliament to restrict street performers (Schafer 1994, pp. 65 - 76). He also describes the rise of technology and its effects on town and cities, drawing largely again on literary sources, and also notes that noise was not considered as "a factor contributing to the multiplicatory toxicity of the new working environments" during the English Industrial Revolution. In giving two opinions for this, Schafer notes that the first device for measuring acoustic intensity was not invented until 1882, but more significantly, he proposes what he calls "Sacred Noise" was now generated by the new force in society – the Industrialists. As holders of power, they were not simply enabled to make the biggest noise, "rather it is a matter of having the authority to make it without censure" (Schafer 1994, p. 76). In the early 20th Century, Thompson observes that the efforts of early acousticians to quantify the extent of noise also served to increase public awareness of the problem, and stimulate expectations that solutions were achievable. Although focussing exclusively on New York, Thompson provides a detailed account of attempts to alleviate noise effects on the sick, sleeping, schools and the wealthy, of noise abatement to improve efficiency, of noise as a disruptive effect on the middle-class vision of a well-run city, and attempts to provide quiet zones (Thompson 2004, pp. 115 - 130).

Contemporary local councils around the world have initiated large-scale projects directed at their acoustic environments, which most often focus on the alleviation of noise as an environmental hazard, and usually through a generalised civic approach exemplified through noise codes, where a blanket rule is imposed on a the municipality. In 2004, New York's Mayor Bloomberg announced a plan to revisit the noise codes, under the aegis that construction, entertainment and business activities should not be as disruptive to New Yorkers.[38] By 2006, the new codes were met with both resistance and scepticism as to their effectiveness.[39] A similar approach is underway in London through *The Mayor's Ambient Noise Strategy.* Design is afforded some status in this strategy, along with integrated management approaches and education.[40] Also appearing in the London report is the term "soundscape", which would suggest a broadening of thinking, further exemplified in conferences as part of the strategy.[41] While both these initiatives attempt to provide solutions to noise issues, the European Commission issued Directive 2002/49/EC on 25 June 2002, "whose main aim is to provide a common basis for tackling the noise problem across the EU." Four principles underlie the directive; the development of strategic noise maps for major noise sources, to assess the numbers of people annoyed and sleep disturbed; informing and consulting the public about noise exposure; addressing local noise issues by requiring local authorities to develop, "action

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38 Gotham Gazette, available at <http://www.gothamgazette.com/article//20040712/200/1034, viewed October 19, 2006.
39 Gotham Gazette available at <http://www.gothamgazette.com/article/environment/20060831/7/1960>, viewed October 19, 2006.
40 The full report, and sections can be downloaded from: <http://www.london.gov.uk/mayor/strategies/noise/downloads.jsp>, viewed October 19, 2006.
41 *Sounder Spaces: The Forgotten Side of Quality?* Conference at London Zoo, Julian Huxley Lecture Theatre, March 14, 2007. Notice retrieved from <www.noisefutures.org/documents/Sounder%20Spaces%20Conference%20Invitation%20211206.pdf>, viewed February 7, 2007.

plans to reduce noise where necessary and maintain environmental noise quality where it is good"; and develop a long term EU strategy to reduce numbers of people affected by noise, in addition to providing frameworks for developing future noise policies. The implementation of the directive spans 2004 - 2013.[42]

What then, are some of the health and social effects of increasing sound levels on those living in urban environments? "Health" has been defined as a:

> … state of complete, physical, social and mental well being and not merely the absence of disease or infirmity. To reach such a state of health an individual or group must be able to identify and to relate aspirations, satisfy needs and change or cope with their environment.[43]

The City of Toronto report, *Health Effects of Noise* (Fong and Johnston 2000) includes an overview of prior research into individual responses to noise, hearing loss, stress induced health outcomes such as annoyance, cardiovascular disease, sleep disturbance, immune and biochemical effects. While the Report focuses on noise, one of its final recommendations is to use curriculum development of materials to promote learning and aural awareness. The Report also offers an explanation as to why sound related issues have not assumed higher importance in general environmental agendas:

> More people are affected by noise exposure than any other environmental stressor. However, because its associated health effects are not as life-threatening as those for air, water and hazardous waste, noise has been on the bottom of most environmental priority lists (Cowan 1994, pp. 14-20).

As the economic and other benefits of replacing reactive measures with preventative initiatives are realised, the relationship between the soundscape and public health is gaining further attention. Many cities are undertaking initiatives to affect their acoustic environments. These range from mapping and measurement[44]; formation of city task forces, for example in Vancouver[45], creation of special entertainment precincts such as those in the City of Brisbane[46], to source reduction via city wide initiatives exemplified in Paris where all garbage trucks will be replaced with quieter models; and heritage initiatives, for example, in Japan where a project has been undertaken to preserve one hundred soundscapes.[47] The City of Melbourne's 2002 Municipal Public Health Plan, states that "The City of Melbourne acknowledges that there are social as well as physical determinates of health. These include economic, environmental and cultural factors and gender." The report also notes that noise is a significant problem for many city residents, representing up to 35% of complaints to the Council's Health Services branch, far

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42 Quote and summary of principles from <http://ec.europa.eu/environment/noise/home.htm>, viewed February 7, 2007.
43 Ottowa Charter, 1986, quoted in City of Melbourne's *2002 Municipal Public Health Plan*, 2002.
44 Information on European initiatives can be found at <http://www.softcom.net/webnews/wed/bs/Aa-quieter-europe.Rudf_DD7.html>, and <http://europa.eu.int/comm/environment/noise/home.htm#2>, viewed February 25, 2007.
45 See <http://www.city.vancouver.bc.ca/ctyclerk/cclerk/970513/citynoisereport/>, viewed February 8, 2007.
46 See <http://www.brisbane.qld.gov.au/BCC:STANDARD:1406176969:pc=PC_2281>, viewed February 8, 2007.
47 See <http://www.sonicartsnetwork.org/ARTICLES/ARTICLE1999GREGG.html>, viewed February 25, 2007.

outweighing “other environmental health issues such as waste disposal, odour and refuse complaints, pest control and illegal discharges.” The Council identifies noise management in the Report as a key issue and a strategy requiring further action. While most of these initiatives concentrate on noise as an environmental pollutant, the listener-centred approach of acoustic ecology seeks to reveal a broader understanding of the ways sound mediates social relationships within an acoustic environment. Westerkamp argues that sound is:

> … the ‘voice’ of a society, of a landscape, of an environment. If we understand the meanings of sound we understand what a place, a society is saying about itself. If we understand the behaviour of sound we can hear how a society behaves towards its environment. If we listen to our own listening, then we can also hear how our own soundmaking in daily life influences the soundscape's quality… (Westerkamp1994, p. 5).

Sound as both force and indicator of dominance is a recurring theme across several texts. Electroacoustic technologies for recording, reproduction, broadcast and amplification of sound have themselves come to dominate the aural experience of contemporary individuals and communities. Ivan Illich draws parallels between silence and the notion of a “commons”, with particular reference to the impact of the loudspeaker:

> ‘Commons’ is an Old English word… which, in pre-Industrial times, was used to designate certain *aspects* of the environment. People called commons those parts of the environment for which customary law exacted specific forms of community respect… On the same boat on which I arrived in 1926, the first loudspeaker was landed on the island [of Brac, his grandfather’s home]. Few people there had ever heard of such a thing. Up to that day, all men and women had spoken with more or less equally powerful voices… As enclosure by the lords increased national productivity by denying the individual peasant to keep a few sheep, so the encroachment of the loudspeaker has destroyed that silence which so far had given each man and woman his or her proper and equal voice. Unless you have access to a loudspeaker, you now are silenced (Illich 1982, paras. 7 & 19)

Listening is variously defined as concentrated hearing, or to hear with thoughtful attention. While we always hear, we don’t always listen. The distinction can be illustrated through the comparison of hearing and seeing: we don’t possess *ear-lids* that can shut down perception of sound, as we can limit the perception of light. The possibility of attending to, or concentrating on the acoustic conditions of a given context, suggests an alternative role for listening in revealing the dominant forces within a society as suggested by Schafer and Westerkamp. By assuming a state of attention, listening might be one counter-strategy against those interventions that attempt to continually distract us from our individual thoughts. These distractions may include those to which author Jeanette Winterson refers when she observed that “Capitalism doesn't want you to concentrate - you might notice that much is amiss. A blurred, out-of-focus consuming is what suits the marketplace best” (Winterson 2002, para. 14).

In this article, Winterson argues for what might be called cultural rights. That is, the right for cultural artefacts to exist extraneous to capitalistic intentions and for our rights to actively engage attention over those artefacts and experience what Winterson refers to as "real presences". The control of the individual's concentration through the acoustic environment by dominant power is described by Jacques Attali as "a means of silencing, a concrete example of commodities speaking in place of people, of the monologue of institutions" (Attali 1985, p. 111). He views the repetition of mass music as the means by which consumer integration, interclass levelling, and cultural homogenisation are achieved. He writes that the presence of musical repetition in the acoustic environments of everyday life – offices, hotels, elevators, factories… "is the music of channelization toward consumption" (Attali 1985, p. 111).[48] In effect, both Atalli and Winterson describe aspects of the effect of technology on the soundscape, the mechanisation of music reproduction leading to the redundancy of flatline sounds and the dominance of the lo-fi environment as defined in acoustic ecology. The field of aural information could thus be said to be so overcrowded, that the resulting lack of clarity tells us little about the environment and serves to silence our own voice within it.

Despite increasing awareness of both the beneficial and detrimental effects of sound on all living beings, the acoustic environment is rarely discussed at environmental forums. Human aural experience is seldom considered within projects and forums investigating built and natural environments. Yet our individual actions and collective interactions impact on the acoustic environment in ways that affect our physical and psychological well-being, general health, ability to work, rest and communicate. As a factor of environmental quality in cities, sound and its effects tend to exist below the attention of most professionals and educators in all but sound-related disciplines. Designers are likely to play a key role in interrupting the un-sustainability of ever-increasing sound levels and ill-considered characteristics of sound in urban environments.

Melburnians are extremely familiar with the concept of the "liveable city "having been accorded *World's Most Liveable City* status in 2002, 2004 and 2005 by the Economist Intelligence Unit.[49] Conditions of the acoustic environment in cities were not taken as a measure of liveability.[50] The categories for Culture and Environment eligibility are listed in Table 5.

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48 The widespread contemporary use of personal music devices would appear to be more pervasive than public address systems for muzak delivery. This makes Atalli's observation no less compelling, except that the individual selects the music sound track as an extension of their right as a consumer-individual to control their immediate auditory field.

49 See *The Age* Newspaper, October 4, 2002. Available at http://www.theage.com.au/articles/2002/10/04/1033538761412.html, viewedNovember 28, 2006.

50 Categories for assessment include stability, healthcare, culture and environment, education, and infrastructure. See <http://store.eiu.com/index.asp?layout=pr_story&press_id=660001866&ref=pr_list>, viewed November 28, 2006. This was confirmed, and the list of 14 categories was supplied in a personal email exchange between the Author and a representative of the Economist Intelligence Unit, Tuesday November 28, 2006.

Items	Categories
1	Quantitative climate rating
2	Discomfort of climate to travelers
3	Level of social or religious restrictions
4	Level of censorship
5	Availability of local sporting events
6	Availability of well known sports events
7	Availability of sporting facilities
8	Availability of quality theatre productions
9	Availability of classic music concerts
10	Availability of modern music concerts
11	Availability of global satellite TV
12	Availability of bars or coffee shops
13	Availability of nightclubs
14	Availability of restaurants

Table 5: Criteria for liveable cities

Items listed for Culture and Environment, Economist Intelligence Unit measures for liveability in cities.

Of notable interest in this list in relation to the *CitySounds* project, is the number of contexts where acoustic conditions and auditory experience would be critical to a more profound measure of liveability than simply availability. Six of the fourteen criteria have a significant aural dimension. There are three categories in the criteria that are also investigated by the *CitySounds* survey (items 12 – 14), and another three specifically covering auditory arts (items 8 – 10).

I have projected here particular issues and opportunities for the emergence of a field of design practice whose aim is to shape auditory experience of space. The projects discussed from Chapters 2 to 5 evolve this line of thinking, in that the auditory artefact of a sound-based practice is not a singularly artistic work, but addresses issues external to itself, some of which have been discussed in this section. Essential to any lasting change in design practices will be a design education that provides the students with the conditions in which his or her auditory imagination can evolve.

1.4 Spatial sound studies in schools of architecture and design

In her Masters thesis investigating the use of acoustic knowledge during architectural design practice, Robyn Lines concludes that:

> … didactic approaches to acoustic education have largely failed to contribute to designers' ability to tackle acoustic design tasks. These attempts to teach a domain

of design knowledge separate from design have resulted in poorly remembered learning experiences often associated with dislike, anxiety and a perceived lack of relevance. The treatment of acoustic education is indicative of its place in the shared appreciative system of architecture designers. Hearing has been the poorly regarded second sense by a visual culture working as a visual medium.

An educational design experience needs to require of students that they can apprehend the design situation, make qualitative judgments about a desirable acoustic environment for the subject space, design an acoustic solution in concert with design intentions and confidently judge the success of the acoustic design (Lines 1997, p. 118 - 119).

In her findings, Lines declares six categories of acoustic knowledge, as outlined in Table 6.

Categories	**Description**
The acoustic design repertoire	Known acoustic solutions or partial solutions relating to forms of construction or materials.
Experience of sound in space	Prior concrete experience, which could be practical, evocative or archetypal.
Visual images of sound behaviour in space	Images that depict the movement of sound in space as a wave or ray and visualising the movement of building elements in response to sound impact.
Function and sound	Using knowledge of the building program and the behaviour of users and equipment to predict possible sound events.
Spatial relations for sound management	Usually involving relationships of volume to reverberation time and role of absorbent materials.
Existing design as reference	Drawn from architecture, and other disciplines such as sculpture and musical noise-making artefacts.

Table 6: Categories of acoustic design knowledge

From Lines, R. 1997 pp. 53 – 59.

We might ask now, if the research into the acoustic environment, auditory spatial awareness and electroacoustic music are ways of thinking about the sounding world, then why are they not formally part of schools of spatial studies? In several instances, they are. As noted in previous discussion, CRESSON and Irec[51] are part of architecture schools at Lausanne and Grenoble respectively. The WSP was part of the communications department at Simon Fraser University, and is now adjacent to the school of geography. Various schools of architecture and design employ composers or sound designers, or run sound-based design studios as part of their teaching programs. The list in the next table provides an indication of schools where

51 Irec was reograrised in 2002, and is now distributed in three institutes. For links see <http://irec.epfl.ch/>, viewed June 22, 2007.

sound features more consistently as opposed to discretely in occasional design studios and other subjects.

University	Department	Centre/Course/ Program/Degree	Reference link
University of Grenoble	School of Architecture	CRESSON	http://www.cresson.archi.fr/
School of Polytechnic, Lausanne	Department of Architecture	Institut de Recherche sur l'Environnement Construit (IREC)	http://irec.epfl.ch/
Rensselaer Polytechnic, New York	Department of Architecture	Graduate programs in Architectural Acoustics	http://www.arch.rpi.edu/faculty/acoustics.htm
University of Sydney	Faculty of Architecture, Design and Planning	Master of Design Science (Audio & Acoustics) and single subjects	http://people.arch.usyd.edu.au/~densil/Audio&Acoustics/index.html
University of Edinburgh	School of Arts, Culture and Environment	Master in Sound Design & Msc/Dip in Sound Environments	http://sd.caad.ed.ac.uk/flash/home.html
University of Auckland	National Institute of Creative Arts and Industries	Acoustics Research Centre[52]	http://www.creative.auckland.ac.nz/uoa/nicai/research/centres/acoustics/acoustics.cfm

Table 7: Sound-based studies within schools of architecture and design

The contemporary strands of sound-based concepts and directions in teaching and research can be seen in the themed streams of the 2006 Ryerson University Conference *Architecture, Music and Acoustics*, of Table 8.

Session	Title
1	Acoustic Ecology
2	Situated Sonic Practises
3	Spaces for Performance
4	Intersections of Music and Architecture
5	The Poetics of Closure
6	Sound in Architectural Education
7	The Architectural Representation of Sound

Table 8: Topics for 'Architecture, Music, Acoustics Conference', Ryerson University, 2006

Architectural design studios, which could be loosely described as sound-focused, appear to fall into the genre or themes of Table 9. These might be the primary theme of the

52 Originally established in the School of Architecture by Emeritus Professor A. H .Marshall.

studio, or a component, for example, a single lecture, or sub-projects over several weeks. Sound might be treated either as the primary program-forming element of the design brief, the subject of an architectural technology study, for example, auralisation, or an alternative experiential vehicle to the visual.

Category of design studios	General description of focus or themes
Sonic based form generators	Where sound or music is used to generate a graphic, either 2D or 3D mapping. The place of design in such programs is usually parameter-to-parameter selection.
Acoustic design	A studio where sound can be understood as data/numerical based for the purposes of a distinct auditory program. For example, a concert hall or place of assembly reliant on signal to noise ratio such as a courtroom, council chamber or lecture theatre.
Acoustic communication	A studio where the spatial design is to enhance or achieve a particular type of auditory communication or experience.
Heightening auditory awareness	Studios conducted with a brief to design a space for blind people. Resonant objects or materials, sound installations or wind chimes, etc.
Virtual acoustic spaces	Sound design for, or in, other media e.g.,animation, virtual reality or games engines.
Soundscape Studies	Projects focussing on analysis and documentation through recording, observation and interviews of interior, urban or natural environments.

Table 9: Themes pursued in architectural studios

Compiled by the Author's ongoing review of local and international design studios. The criteria of selection was that the host school must be design-based, not an engineering or science faculty.

As precedents to aural training of spatial designers, it is useful to consider auditory education in two related disciplines, and an intriguing theory from cognitive neuroscience. Aural training for musicians is an embodiment of musical materials or parameters using vocalised and physicalised exercises, focusing mainly on pitch and rhythmic apprehension. Exercises consist of melodic and rhythmic dictation, sight-singing, and recognition exercises, short compositional exercises and 'real-time' manipulation such as transposition. This training of musicians is an experiential learning approach combining listening, performing and analysis. Students must physically engage with the materials of their artform. The second domain is the training of audio engineers, particularly related to memory of timbre sensitivity and difference. Recent papers in the audio engineering literature (Kassier et al. 2004) have discussed pedagogical resources to develop auditory awareness of audio engineers, and amongst other observations, identified the need for continuous practice and exposure to relevant auditory material, otherwise, "skills atrophied without periodic practice" (Blesser 2001, pp. 889). New theories of auditory scene models are emerging that might prove extremely useful if adapted to teaching other spatial disciplines.[53]

The embodiment of materials through physical effort, and the need for continuous aural practice find a contexualising frame in an observation drawn from differences in visual and auditory experience of space. As put forward by Stein and Meredith, spatial representation is achieved by the visual and somatosensory systems as "each peripheral nerve fibre responds to a stimulus in a restricted generally contralateral spatial domain, regardless of stimulus intensity, and this defines the cell's receptive field" (Stein and Meredith 1993, p. 93). In contrast, auditory representations of space, unlike visual and somatosensory ones, are constructed via computational processes. The spatial auditory map is the "result of a computation based on the differences in the intensity and timing of sound as it reaches the two ears" (Stein and Meredith 1993, p. 93).

Considering these observations together has significant implications for aural studies in design pedagogy, and the potential emergence of new spatial experiences. It would appear that for an auditory pedagogy to take hold in the practice of designers will require teaching and learning exercises that embody the experience of auditory space; include critical exercises through which to understand the scope of auditory perception and its relation to other sensory systems, the development and application of aural memory, and the discovery of generative acoustic design methods. If, as Margaret Wertheim has asserted, that "our spatial schemes are not only culturally contingent, they are also historically contingent…" (Wertheim 2000, p. 307), the contemporary convergence of electroacoustic practices with spatial studies might be the catalyst to generate new concepts of spatial design and experiences in built and digital space. However, for such a renegotiation of spatial concepts to occur, design pedagogy must embrace the unique needs of an aural training for architects.

1.5 Practice as individual sound artist and artistic director

My original motivation for commencing a PhD in a school of architecture and design was to access a body of knowledge not readily present within musical discourse. I was also interested in the ways auditory culture might advance beyond music and arts-based practices such as installations. *SoundSites* was the first large-scale project I completed after four years working in various curatorial and artistic direction positions with arts organisations. This project marked my transition from individual practitioner to the first stages of working in a research environment. Prior to *SoundSites,* I worked on projects with Contemporary Music Events, Next Wave Festival, and the Australian National Academy of Music (ANAM). During this time, my work encompassed the plethora of tasks required for programming and direction of electroacoustic concerts, installations and workshops in a festival structure. This brought me into close contact and intimate knowledge of the work of over sixty composers and sound artists spanning the four years from 1996 to 1999.

53 Interestingly, the basis for selecting attributes of descriptive analysis in audio related experiments was research adopted from the food science industry.

Such a large range of works obviously exhibited an equally sizeable spectrum of artistic and technical foci. The repertoire included works of Twentieth Century composers including Luigi Nono, Karlheinz Stockhausen, Iannis Xenakis, Denis Smalley; classic acousmatic works, alongside those of emerging composers. All concerts were produced on large-scale spatial sound diffusion systems. These events and exhibitions were played out as cultural events to a large extent. In the case of ANAM, an educational component existed in the form of workshops and tutorials for students in the presention of live electroacoustic music. Students in this programme had either recently completed, or were in final years of tertiary music performance degrees in conservatoria around Australia.

After the experience of curating many works from other composers and sound artists, I returned to my own work with at least three themes of practice:

- The production of the electroacoustic cultural artefact (work, concert, installation, CD) as an intensification of our aural experience in the world.
- The propositional work that provokes a reflective reaction about alternatives for the design and experience of acoustic environments.
- To produce work from a community and collaborative-based process, to expand my practice from the rarefied atmosphere of electroacoustic music studios and concerts, by more broadly adapting my professional skills to other non-arts contexts.

SoundSites and *CitySounds* exemplify the first and third themes above, while the *Canopies* installation immediately following *SoundSites,* arose from the second theme.

In addition to my own creative and curatorial practice, I also pursued a project between 1995 and 1999 to establish an independent electroacoustic music studio. Melbourne places an emphasis on art and culture as an intrinsic part of the City's national and international identity. All major contemporary artforms are supported by State and Federal-funded infrastructure or service organisations such as writer's centres, visual art galleries, contemporary music ensembles, dance companies and new media organisations. This carries an implication that the continued investigation of artform practices, for their own sakes, is ensured if only through the provision of production and other support infrastructure and expertise. More recently, the Victorian State Government has made substantial investment in the design industry; its education and research along similar lines. In 1995, I was awarded a Winston Churchill Memorial Fellowship and Australia Council Professional Development Funding to investigate the operation and management of independent studios in Paris, Amsterdam and New York. The project to establish such a studio would have been the first of its kind in Australia, however, funding proved ultimately elusive and in early 1999, I conceded that it was not to be, which provided another impetus for changing my career trajectory through the commencement of a PhD. Ironically, soon after starting at RMIT, I became involved in a project to establish the Capitol Soundscape Centre, to be housed in the Walter Burley Griffin designed, Capitol

Theatre in Melbourne's CBD. This Centre was to exist in order study "all aspects of the human aural experience." (Capitol Feasibility Study, JTP Enterprises, copy held by the Author).[54]

The model was based onan organisation I had studied in Paris – *Les Ateliers UPIC* – and researched elsewhere. It consisted of a small team, studio space, an education program, research program, concerts and publications. These centres were independently funded and managed, although often working collaboratively with each other for events, or resource and infrastructure sharing. This model is one I have continued to pursue and is the background to the final project of this PhD, discussed in Chapter 6.

I am fascinated by the notion of visual culture. It is a parallel universe to my own auditory-focused one. My daily contact with visual practitioners is through working in a school of architecture and design, and in a university supporting visual art and design schools, as well as other professional and personal associations. I've noticed how ideas embedded in forms and images are freely traded across the discipline divides of visual art, fashion, architecture and design, film and media. So much so, those practitioners of these closely inter-locking communities readily refer to visual culture in their vernacular as a "shared space of practice". The parallel conversation about auditory culture, or aural culture within Melbourne is not so ready. If it were, it would encompass the sound exhibitions and installations, physical acoustic conditions of public spaces, unique features of the soundscape, musical affordances and mix of languages. For the Author, a central role of an institutional studio and the sound designer is to be the catalyst for such a conversation in the public domain.

Conclusion : toward an emerging design practice

The interdisciplinary nature of acoustic environment research provides a context through which electroacoustic practitioners might engage with environmental, social, design and cultural domains. While the engagement Western cultures predominately have with their acoustic environments displays an imbalance between human need and environmental conditions, other non-Western cultures have achieved sophisticated auditory relationships with their immediate acoustic environment. Contemporary practices of spatial sound design are characterised by affordable technologies, accessibility of a plethora of information and software tools, and projects ranging from sound design for domestic 5.1 formats, to the scale of built and urban architecture. The work of these sound designers can be considered a community responsible for establishing and maintaining spatial concepts particular to auditory experience. But like any aspect of our spatial world, there are social, health and cultural factors that shape the acoustic environment, of which designers and researchers must be cognisant. If urban environments are to be sustainable, the acoustic environment must be a factor in determining the qualities of human experience in those environments.

The potential position of sound-based practice as a spatial design discipline has come about through two interrelated modes of research. The first is in auditory spatial awareness of

54 Even this project had an earlier gestation period in a project I was leading to establish an independent electroacoustic music studio in Melbourne. This project had been the purpose of a Churchill Fellowship and Australia Council funded international study tour in 1995-96.

listeners in various environments, and the second, through creative practices focussing on the production of spatial sound works, primarily for cultural milieux. Research in the first mode developed and extended the notion of the acoustic environment, the ways it is constructed and maintained, and social and health implications of balanced or imbalanced acoustic environments. Extending beyond acoustics, practitioners may now consider the communication and aesthetic dimensions of an environment, as a 'designable' component of space. Through projects in the second mode, sound artists, composers and acoustic designers have created speculative and representational works, at the scale of architecture, urban design, for cinemas and other new media, the home or the portability of headphones which are now part of the auditory spatial experience of listeners in cultural and quotidian milieux.

2.0 Auditory Spatial Design in Electroacoustic Projects

Introduction

Between 1999 and 2005, I completed five spatial sound design projects. The purpose of this chapter is to describe and analyse the completed form of the five projects, before moving to a discussion of their making and qualities in Chapters 3 and 4. The link between this chapter and the next two is intended to also demonstrate that the transformation of my practice from composer-sound artist to spatial sound designer was articulated through a series of works situated in diverse milieux, and with a diversity of creative demands. Through these projects, I have sought to better understand design processes for making spatial sound projects. My intention in making such projects has been to engender in listeners an auditory spatial awareness not just of the work or project *in situ*, but also of their quotidian experience of the soundscape. The scope of this current study has necessarily been limited to the production of the works, not to an exhaustive study of the success or failure of the works to engender listener awareness, which I see as a long-term project best undertaken through a centre of practice such as that described in Chapter 6.

Canopies chimerical acoustic environments was a work that demanded a coherent sustaining concept, due to the external factors on the work, including unusual delivery technologies, the physical conditions of the site, widely diverse site use and historical issues of other soundscapes on the host Southgate precinct. For *Symbiosis,* a formal analysis of the chambers is presented, supported by sound examples and graphic scores, whole sections, reductions of layers, and individual sound materials. Descriptions of the *Symbiosis* visual environment is included, along with my approach in designing the multi-channel soundscapes for each chamber, and comparison of the chambers between themselves. Like *Symbiosis*, *Canopies: concert version* is a work heavily reliant on pre-rendered sound transformation and spatial sound diffusion. The majority of work for *Ecstasis* was software development in the Max/MSP programming package, and I describe the key components and ideas of an integrated environment for delivering a spatial sound design in real-time. *K* is included to exemplify the diverse milieux or expanded practice of my work based on purpose-built software exemplifying a distinction between the primary activity of crafting sound files and the making of software control to achieve a similar set of sonic aims.

The production of the five projects is closely intertwined. The first collaborative exercises and soundscapes of *Symbiosis* were reliant on sounds produced for *Canopies.* Early stage production and programming on *Ecstasis,* was suspended for the first performances of *K*, in Melbourne. However, Max/MSP patches were interchanged between these projects. Each project was developed within collaborative partnerships that included new media artists, theatre directors, performers and designers. Solving technical and design issues to complete a spatial design are common to all works and discussed as separate sections below. In all projects, the qualities of the sound design and its relationship to the listener were a key part of the projects. In *Symbiosis* and *Ecstasis*, this is played out as a sound design enveloping a stereoscopic projection. In *K*, it is sound used to create an acoustic set in a theatrical production, to position characters in a play in distinct power relationships, expressed through their degree of pressure on the environment. In *Symbiosis*, this encompasses the production of 8-channel soundscapes for stereoscopic projections by adapting limited technical resources for spatial sound design production and presentation.

2.1 *Canopies*, chimerical acoustic environments

Description and initial concepts

The Southgate Soundscape System rests on the edge of Melbourne's CBD, separated from the city by the Yarra River. The soundscape system was installed during construction of the precinct, and at the time of *Canopies* it was managed by Nigel Frayne of the company *Resonant Designs*. The one hundred and sixty loudspeakers of the system extend along the promenade for around one hundred and fifty metres and except for a wider central section, are spread over a width of approximately ten metres. The loudspeakers are visually integrated into other architectural features of the site in three layers; the highest are embedded into the balustrades of the first floor balcony, the next highest are mounted on light poles on the promenade, and the third are built into a fence mounted about three hundred millimetres above the footpath. This speaker configuration, particularly the two levels above the listeners, suggested a covering suspended or held overhead, that is, a canopy.

Canopies was based on a simple premise - to interpolate a series of electroacoustic environments into the Southgate precinct composed from the essences of the natural soundscape. I was not interested in following the model of previous work on the site, where actual recordings of natural habitats had been widely used. My personal critique of this approach was that recordings were too literal, and created a disassociation from the actual built space the listener inhabited, a concept closely related to Schafer's schizophonia (Schafer 1994, p. 88). The notion of essence was critical. In the first instance, I wanted to investigate my own auditory reading of natural environments, to treat these environments as compositional models re-imagined through my own auditory imagination and design practice. This essence, I suspected would be in the temporal and spectral qualities of sounds in these environments, and also comprised from motions of sounds in the environments. The content of Table 10 appeared in the original application, to indicate some of the movement-spatial qualities that would characterise the chimerical environments.

Motion	Description
centrifugal	development from inside out
centripetal	development from outside in
scattering and gathering	textures of points that break apart and coalesce in time and space
waves	cyclical variants of a parameter, for example, timbre and amplitude
streams	flows of a single type, or layered with others
vertical-horizontal integration of sound	using the vertical differences in the speaker locations on site with static sounds
ascents - descents	as per previous item but with panning through the vertical
approach - recede	effects of proximity to the listener
static - dynamic	contrasting sounds at rest, and in motion around the listener

Table 10: Canopies early ideas on spatial motion

Reconstructed from a list in the original Canopies application to the Southgate texture program, some descriptions have been expanded here.

The idea of chimerical environments sets the work apart from muzak, which insists on a particular emotional reaction from the listener. *Canopies* avoided the use of direct recordings of natural sound, although the spectral and temporal organisation of the chimerical environments were closely related to – but not mappings of – natural environments. To that end, the term "chimerical" was used in its literal meaning of fictitious, fanciful, fantastic, fictional or illusory. *Canopies* is designed for a transitional space, a type of space where listeners are usually in motion. This might be a stairwell, an arcade, or the promenade of a riverside. The work was designed to create a detailed mesh of sounds in an urban environment, where the sounds often hover just above the threshold of aural perceptibility. That is, they are not conspicuously present on the site through the use of high levels of loudness.

Existing site conditions

The Southgate Promenade is not a concert hall where there are several known aspects to the listening conditions. For the most part, concert hall music begins and ends at a certain time; people sit in a contained environment, and the hall probably has a purpose-built acoustic for several desired musical contexts for example, 18th - 19th century, small or large ensembles. Visitors to Southgate move through the site with many temporal variations made from running, riding, skating, walking, sitting and dining. The site is also flooded by the city soundscape presenting several temporal and spectral layers affecting a sound work:

- a constant low frequency din from traffic, plant equipment (air-conditioners)
- sound from a major construction project then underway at Federation Square
- train sounds from adjacent Flinders Street Station
- boats (tourist barges) passing and idling at a wharf in close proximity
- general sounds:- people talking, mobile phones, skate boards, birds, buskers...

In contrast to these conditions of predominantly low and constant sounds, *Canopies* is made from timbres that are mid-to-high pitch range, richly textured and varied. The optimum frequency response of the loudspeakers on the site is between 400 and 4,000hz. The sound sources for the work included transformed recordings made from a set of wood-chimes, a collection of shells, a set of beads and small brass bells and cymbals. The chimes, shells and beads were selected for their potential to create dense sonic complexes and are pictured in Image 2 on page 76. Other material was created from various synthesis techniques and transformed vocal improvisations.

Video example 1: Canopies video from site installation

This footage was made just after the Canopies installation opened in early 2000 and is intended to convey a sense of the spatial qualities of the site, its setting alongside a river in central Melbourne, and the level of pedestrian and other activity on the site. The actual Canopies installation can be heard in the background, however, for an example with improved audio quality, listen to Sound example 2: Canopies walkthrough, page 80.

The transposition of spatial experience: modulating exterior conditions to interior qualities

Rapid developments of electroacoustic technologies during the 20th Century applied to music production and diffusion have expanded the number of site typologies where music is heard. The field of acoustic ecology defines an acoustic environment as the perceived area encompassed by a soundscape, either an actual environment or an imagined one as produced with a tape recording and several loudspeakers. A location such as the Southgate precinct provides both environments, one embedded within the other. The use of recording, reproduction and loudspeaker technologies, means an electroacoustic sound source, placed anywhere in the built environment, in one sense, breaks the traditional dependence between listening contexts and interior architectures. It is now possible to introduce an array of sonic experiences from electroacoustic music into any architectural space.

In the *Canopies* project, I was interested as to how the spatial experience of listeners might be transformed by highly-crafted electroacoustic sounds introduced onto the Southgate site. During the Project, I began to imagine that the electroacoustic environment along the promenade might be used to create an interior condition (or quality) on an exterior site. These conditions of interiority would be richly textured in a way usually associated with a composed work for concert performance, or the polyphonic calls, cries and complex textures found in natural acoustic environments. The exterior conditions would be the existing soundscape of the city. The chimerical acoustic environments, composed of sonic events of an ambiguous source, would determine the interior qualities. To that end, the sense of interiority created by *Canopies* would echo architectural interventions such as amphitheatres, sound shells and music bowls, or places for respite such as sunken or walled gardens, designed to partially envelope a listener, and provide a sense of enclosure from other urban conditions. *Canopies* differs from these interventions, particularly those designed to ensure clarity of musical or vocal source such as an amphitheatre or sound shell, by being an active intervention, as opposed to a passive or responsive architectural articulation of acoustic space, caused by the responsive interactions of geometry and materials. Where acoustic design is used to determine architectural performance affecting sound reflection, diffusion, diffraction, absorption, and transmission paths, sound design, in the case of *Canopies,* determines the myriad of sonic textures and gestures, and the spatial qualities they weave around the listener on the Southgate site.

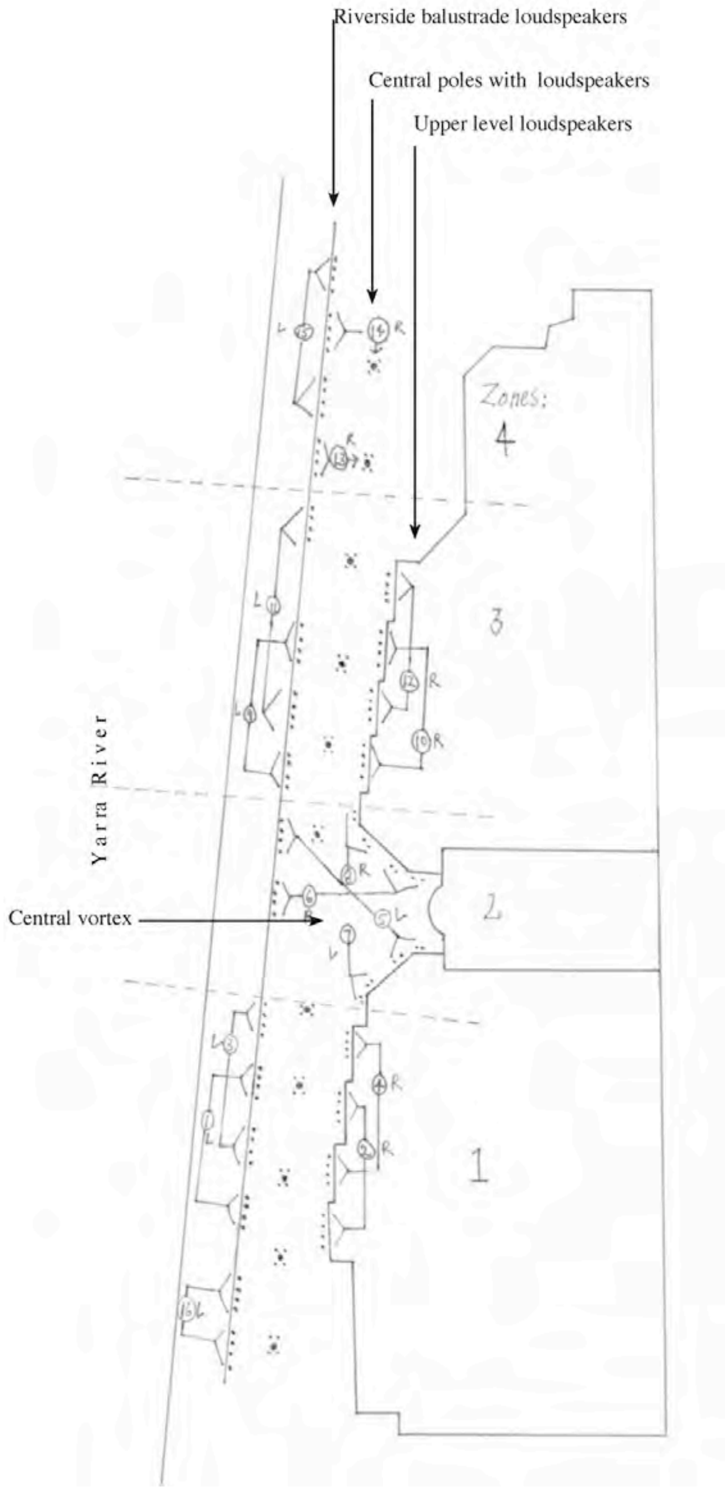

Figure 3: Canopies *site plan*

View of Southgate Soundscape system showing speaker configurations and zone groupings used in Canopies. *The vortex is in the centre of the image, to the left of the zone number '2'.*

In mapping soundfiles to loudspeakers and zones, loudspeakers were 'paralleled' but matched to their opposite locations for stereo effects on the site, indicated by 'L' and 'R'. The central area with diagonally crossing lines in front of zone 2 in Figure 3 is the central atrium, which also appears in Image 3. The circled numbers in Figure 3 refer to the output busses of the main soundscape system. Further mixing or intermingling of files was achieved on site by interleaving these busses. The line of larger dots surrounded by four smaller ones are the central poles each with four loudspeakers, and the upper balustrades are on the right hand side. Although the full capacity of the system is 156 loudspeakers further maintenance was required at the time on some of the central poles, to make those loudspeakers active. *Canopies* used the 120 loudspeakers along the balustrade, two of the central poles and the upper balcony.

Image 2: Canopies, *recording hutch and objects*

Hanging from the blue triangle at rear are small beads, the bamboo chimes are on the floor near the microphone, Indian finger cymbals and small bells are at rear-right of image.

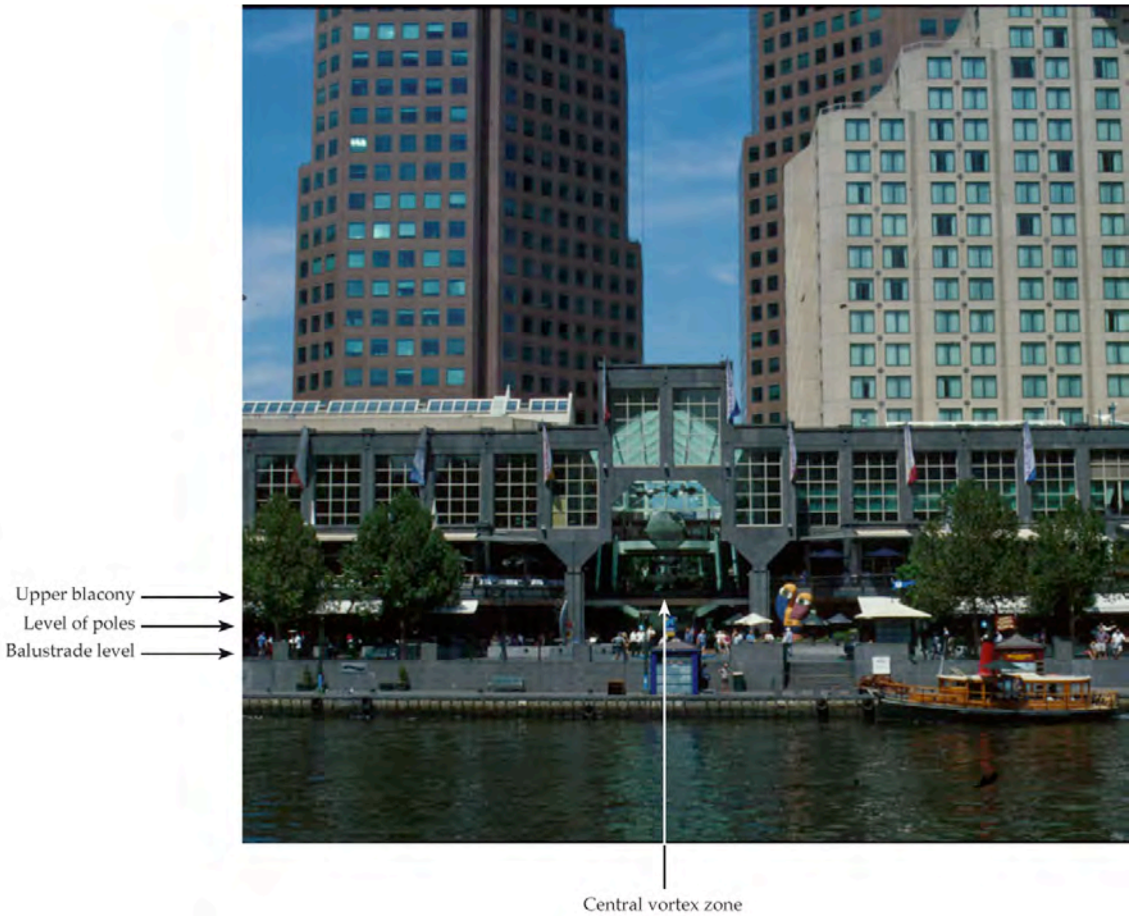

Image 3: Canopies *Southgate Precinct from Flinders Street Station*

View from the opposite bank of the Yarra River. The central atrium can be seen in the middle of this image, as can the upper balcony on the first floor where the higher layer of loudspeakers are embedded. The soundscape system stretches beyond the boundaries of this image.

Image 4: Canopies *Southgate Precinct from onsite*

Site for Canopies *installation, the balustrade to the right contains the lower series of loudspeakers. The central light poles can be seen on the left, partially obscured by trees.*

Image 5: Canopies *site details*

The row of circular objects attached to the floor of the upper level in this image are the higher loudspeakers of the soundscape system.

Organisation of timbre sets

The number, size and organisation of the timbre sets were not closely predetermined but evolved during the studio sessions over the summer of 1999 - 2000. The sound qualities used in the brief of the original commissioning application provided a framework for their design, as did the selection of source objects and gestures. The final determining factor on this organisational approach was the soundscape system itself, which is built around the notion of a player to which a file or files are assigned and selected according to a number of modular or random strategies. As I did not have access to the delivery system in the studio, but did have to design the components of the work to be heard as an ensemble, using timbre sets supported development of a larger structure from discrete files. Further discussion of these elements appears in Chapter 4: *Creating the palette for Canopies: chimerical acoustic environments*. The selection of sets and individual files within sets was all managed within a section of the soundscape system (see Image 7). Sixteen timbre sets were developed for the final work ranging in size from four to thirty-five audio files per set. The workbook scan in Image 6 show notes made on site during installation of the work along with zone mappings and number of files per group.

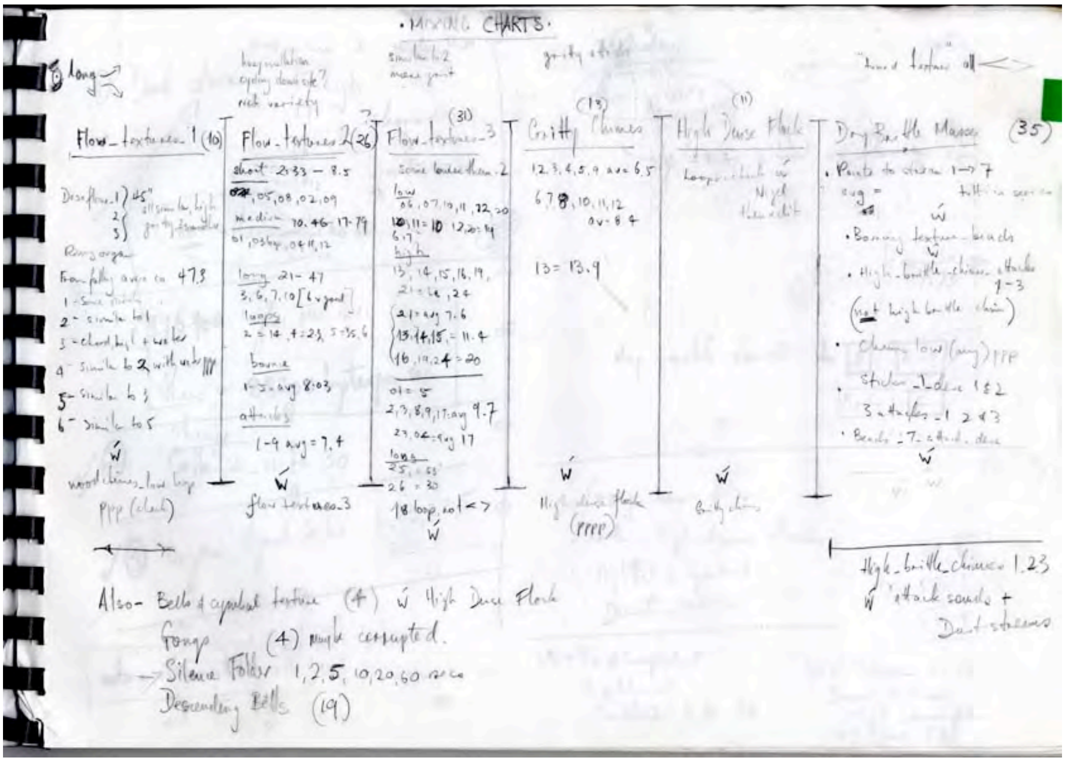

Image 6: Canopies *scans from workbooks*

Each column contains notes about a timbre set named at the top of the column. Other numbers refer to the bus numbers to zones on site. A print version of these sets appears in Table 21: Canopies chimerical acoustic environments palette

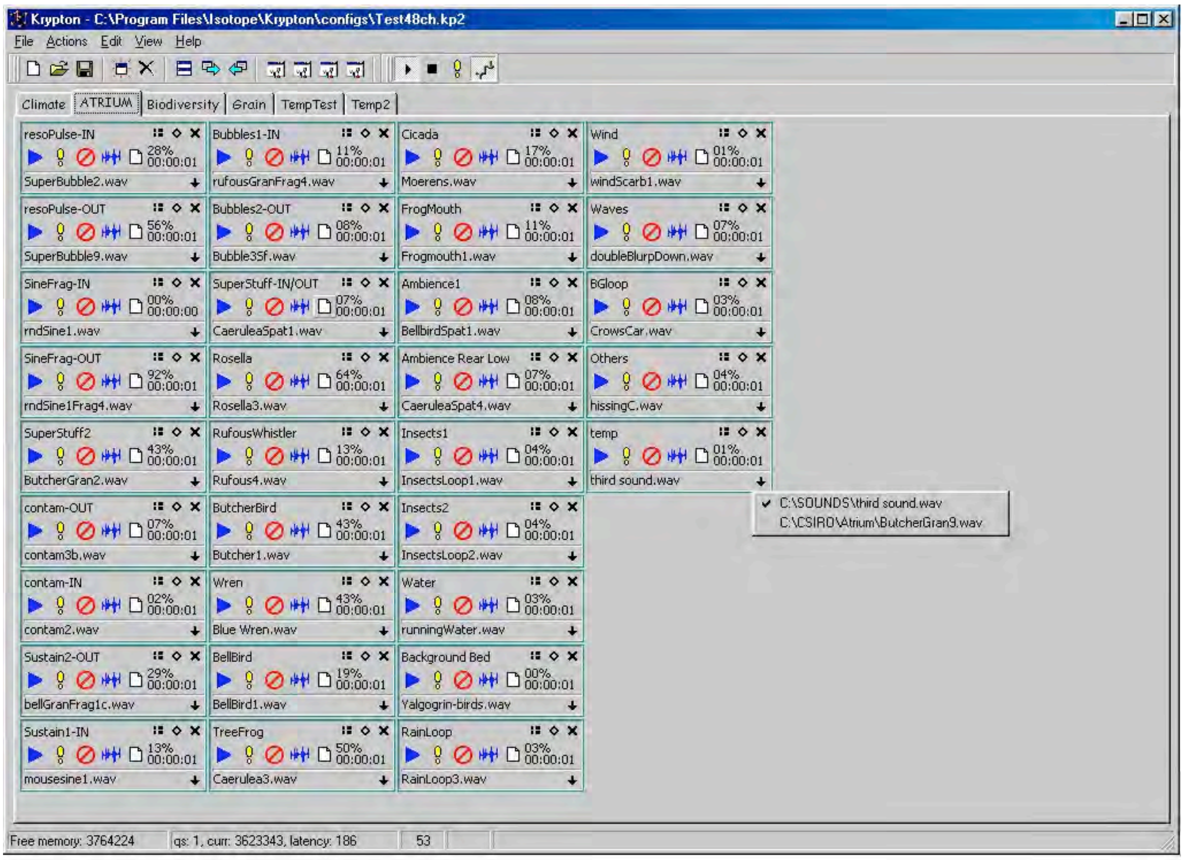

Image 7: Krypton system window of players

This screen snapshot is from a different project, however the drop down menu to the bottom right of the players shows a small pool of two files in a player. The company Resonant Designs *developed the system. Image courtesy of Nigel Frayne.*

Sound example 2: Canopies *walkthrough*

This example comprises a site recording of Southgate and material from the original palette of the Canopies *installation. The site recording appears in channels one and two. The* Canopies *material is in channels three to eight. To compare the site and* Canopies *material, use the mute buttons to the left of the screen to remove either the site recordings, or some or all of the* Canopies *material.*

2.2 *Symbiosis*

Symbiosis is a forty-eight minute work comprising six eight minute, eight channel 'indicative soundscapes' for a virtual reality work. The term "indicative soundscape" was employed to describe a technical work-around for a series of issues discovered during the making of the Project. The visual components of the Project were stereoscopic projections of three-dimensional chambers designed by the two other members of *Metraform*, architect Jonathan Duckworth and new media artist Mark Guglielmetti. We formed the group *Metraform* at the start of the *Symbiosis* project and we were later successful in attracting large grants and commercial virtual reality production projects, along with national and international exhibitions. Highly abstract in nature, the chambers of *Symbiosis* are proposed as contemplative spaces. The work was produced for RMIT's Virtual Reality Centre (VR Centre), and originally shown on a curved screen and eight channel sound system. While the chambers can be navigated freely, or via a set path, the soundscape is of set duration and neither automated nor generative in any way, although the materials are indicative of what was intended for such a version. The chambers are described here in the order of their original showing for the Melbourne International Film Festival (MIFF) in July 2001.

Collaborations tend to invent a language, and there are two terms from this project that require a short explanation. We referred to a 'run' of the work as an *experience*. This vernaculardeveloped from Mark Guglielmetti's observation that the gentle motion through the work, and absence of events other than the audiences' own experience could be described as "the speed at which nothing happens." In fact, despite being a screen-based work, there are almost no moving images on the screen. It is the viewer's portal into the work that is gently in motion. As inside the environments, little actually occurs, the viewer experience is, in fact, the content of the work. Our evidence of this was repeatedly confirmed after talking to audiences at the end of a 'run' during the MIFF shows. Some would ask what *Symbiosis* was all about and we would immediately revert the question and inquire as to their own experience; what they thought, heard or saw during the show. In all cases, a lengthy description would ensue concerning space, textures, and apparent visual-aural synchronicity; sensations of floating or immensity, of space moving through the viewer. The second term is *chamber* and refers to the actual space of the experience. It comprises a 3D model traversed by a set camera path, although for some later showings of *Symbiosis*, we adapted the *Ecstasis* head-trackers so audiences could self-navigate.

Nebsphere

As the first chamber in the *Symbiosis* cycle, *Nebsphere* sets the perceptual conditions for the work. One function of the soundscape is to articulate an auditory spatial stage or setting of sound around the listener. At the start of the work, the VR Centre is close to fully darkened. Before *Nebsphere* is visible, a few opening credits appear. This first chamber of *Symbiosis*, viewed on a curved screen in stereoscopic projection, appeared to have a marked affect on audiences. The scale of the environment is ambiguous. It could be an immense interstellar space, or a microscopic world enlarged for the viewer from its original cellular scale. In designing the soundscape, I did not attempt to clarify the sense of scale for the listener, but chose to sustain this equivocal acoustic state.

The *Nebsphere* soundscape opens with two contrasting layers, a set of short metallic signals or calls over a complex ground or drones sound. In Image 8, the drone can be seen as the four longer sound files, surrounded by clicks appearing as thin lines. Both layers operate in two different ways. The call signals are short blips, reminiscent of sounds from short-wave radio communications or 'chatter', while others evoke insect-like piercing tones. Many of these calls originally appeared in *Canopies*. The function of the call sounds is to immediately articulate a circumambient field of points around the listener. It is an announcement, a proclamation that the auditory narrative space extends beyond the boundaries of the screen to envelope the listener.

Sound example 3: Nebsphere *opening call sounds*

This 6-channel example contains only the opening call sounds from Nebsphere *that appeared in all loudspeakers around the audience. The drone textures appeared in channels 5-6 and 7-8, in loudspeakers at the front of the audience under the screen, and at the rear of the presentation space. The speaker layout for* Symbiosis *is shown*

Figure 16.

The aural image I attempted to create with the second drone layer is of a slowly revolving object emitting or 'splaying out' a wash of timbres, somewhat like solar flares flung out from a central core of energy. It is reminiscent of the Indian stringed instrument, the *tamboura*. This sound is also a platform for motion that carries the listener through the experience of watching the work. At the opening of the forty-eightminute show, this sound is intended to immediately plunge the listener into a mesmerising set of aural conditions. The time-stretched metallic texture continually shifts colour and spatial perspective, at times dominating the aural field, at others being swamped by other sounds positioned all around the listener. The subtle undulations of the timbre engender a sense of motion, of transition, of change in a seemingly static experience. Although the sonic palette of the eight minute piece is presented in the first fifty-five seconds, a sense of periodic repetition is difficult to detect throughout the remaining work. The slow undulations of the drone-like tone, while at first appearing to be static in nature, allow the ear to scan its texture. This process of scanning slowly over a vista is very similar to the process I find in watching the images of *Nebsphere*. It is as if the ear is being invited to trace an independent path of the eye.

The process of finding and matching call sounds that would suitably work as an ensemble required an audition process. Listening to these sounds some years later, I can detect the complex detail that makes them appear energised by the environment. It is as if the presence of the audience has caused a flurry of communication within the environment. The sounds appear to be variations of others, or completely contrasting, as if emitted from a different organism, or communicational process. The overall impression is always one of being surrounded by a communication system or network over the slowly evolving drone. In Image 9 from my work-book, are notes from a process to audition sounds. I note spontaneous impressions of qualities in the sounds, particularly unique features for example, "grainy slowish", "OK – some 'atmosphere'" – "filth". However, in responding to the meta-theme of contemplative chamber, a sense of slow unfolding always underliess *Nebsphere*.

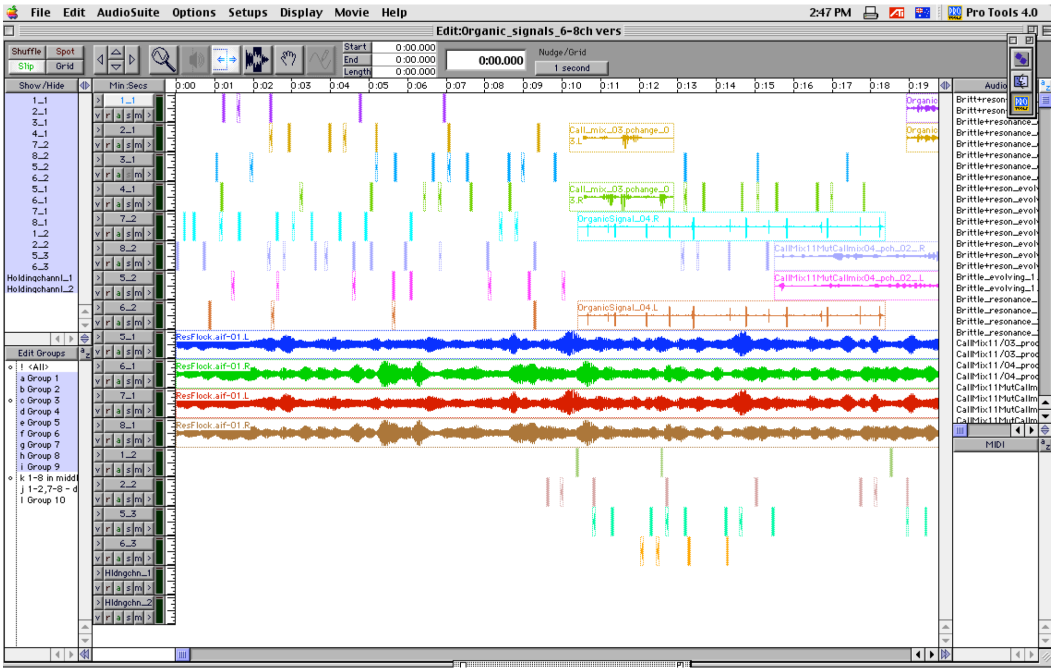

Image 8: Nebsphere *screen Pro Tools session*

The opening 35 seconds with clicks appearing in this image as thin lines in the upper left and lower middle of the session file. Individual clicks were panned to locations around the audience. The drone files titled 'ResFlock…' can be seen in the middle of the session, and were panned to four ground floor level loudspeakers around the audience.

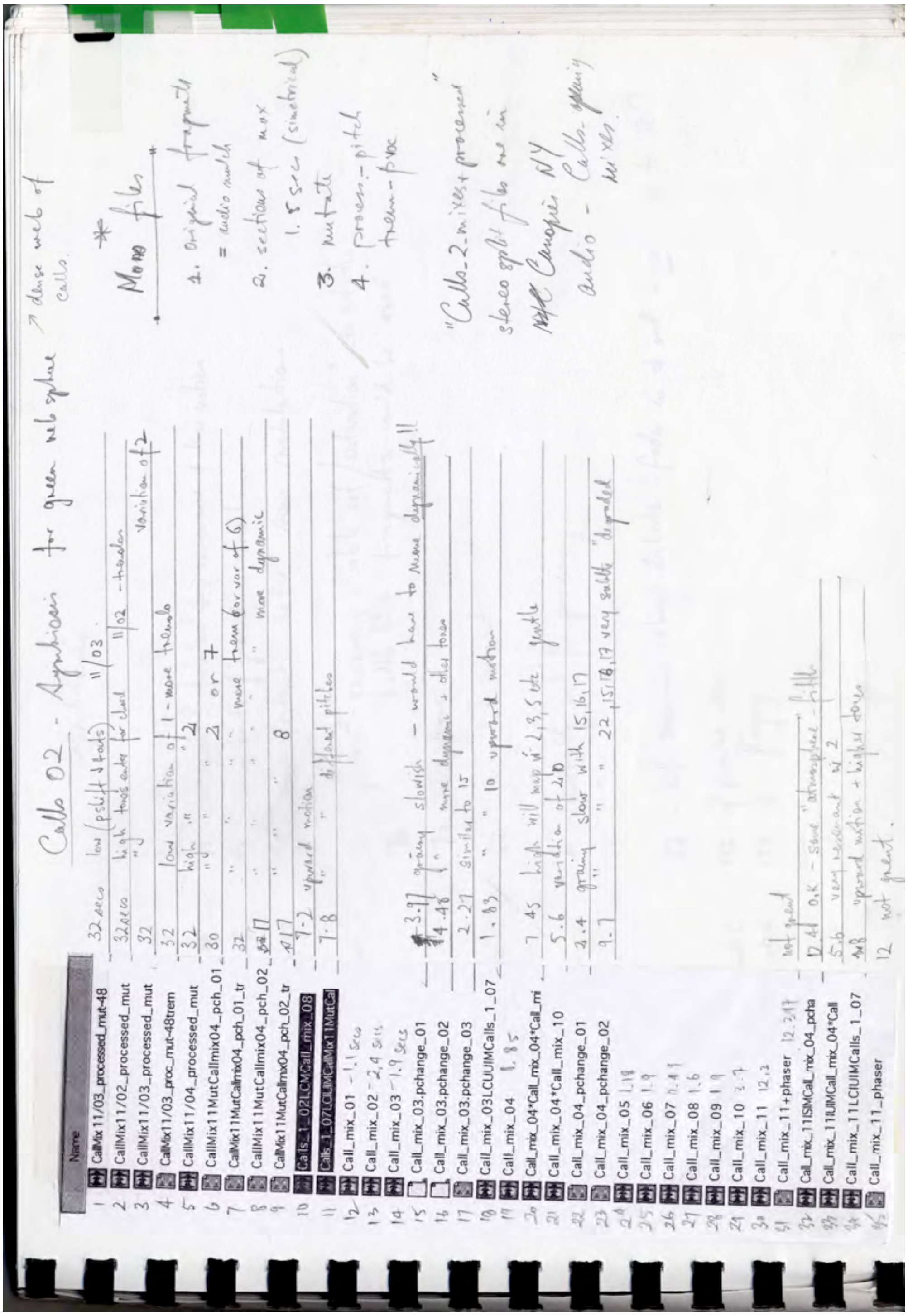

Image 9: Symbiosis *scan of work-book*

Audition notes for Nebsphere. *The printed list on the left is a screen capture from the folder holding the call sounds. The notes to the right are further descriptions used to compare and select which sounds would be used for the opening of* Nebsphere. *This process of selection would often take place days apart from synthesising sounds, a practice I find gives ones' ears some distance from the original impressions that may be too hastily formed during creation of the sounds.*

Sound example 4: Nebsphere *from* Symbiosis

Modelkit

Where *Nebsphere* contrasts two distinct layers, *Modelkit* is built on a set of variations derived from shaped resonant noise streams. Only two sound sources are used; a single noise stream transformed in various ways, and a gritty textural sound originally created on the UPIC[55] system and transformed in the GRM[56] Tools sound-processing program. The resonant noise streams oscillate between distant perspectives and near field locations while the gritty texture appears only at the end of the work spiralling around the listener and dominating the foreground. There is no attempt to resolve these textures in any way, or allow them to interact except by contrast.

The visual environment for *Modelkit* is a grey fog-bound 'model-kit' of objects collected from male culture and readily identifiable with familiar male identity. The objects are held on a simple cube, whose geometry is revealed to the audience over time, as the camera takes a circuitous path around and through the objects held on the cube. The visual environment is limited to colours from grey hues to white. The soundscape is designed to provide an equally understated auditory quality to the experience of this chamber.

The morphology of the original noise source has been shaped into various arching forms, intended to invoke comparisons with environmental phenomena, a wind gust, or a wave motion. This brings another layer of perceived movement in what would otherwise be a predominately static experience. These textures advance and recede on the listener, and undergo various transformations such as stereo panning modulations and resonant filtering. These effects create subtle timbral transformations to the sound, without disrupting an otherwise static experience.

55 UPIC is the acronym for Unité Polyagogique Informatique du CEMAMu. The CEMAMu (Centre d'Etudes de Mathematiques et Automatiques Musicales/Center for Studies in Mathematics and Automated Music). I worked on this system during two residences at the CCMIX (Centre for Composition of Music Iannis Xenakis, formerly Les Ateliers UPIC), Paris in 1995-96, and later in 1997.
56 Group de Recherche Musicale, also based in Paris.

Sound example 5: Modelkit *stream sound variations*

Sound example 5.1 (Modelkit-Ex-1) is heard early in the work, and is characterised by a swooping gestural quality. Sound example 5.2 (Modelkit-Ex-2) begins with a static quality but with some sense of gentle pulsing with an overall 'flatter', less busy amplitude envelope. In contrast to the first example this example has a more metallic timbre and less prescence of noise. Sound example 5.3 (Modelkit-Ex-3), the shortest of the three variations, also begins in a static fashion but with some of the motion qualities of Modelkit-Ex-1. Sound example 5.4 (Modelkit-Ex-4) has the least internal movement of the four variations. The stereo 'flutter' variations can be heard in Modelkit-Ex-5-modulation, while Sound example 5.6 (Modelkit-Ex-6-low) is a simple crescendo-decrescendo of the main texture, used in the final composition as terminating gesture to other more dynamic variations. A variation created by moving a filter through the main four variations presented above can be heard in Sound example 5.8 (Modelkit-Ex-7-filter-ascending). This example also provides a contrapuntal higher terminating motion to Modelkit-Ex-6-low. A short example of the brittle swirling texture heard at the end of ModelKit *can be heard in Sound example 5.8 (Modelkit-Ex-8-brittle).*

The challenge in making the *Modelkit* soundscape was to construct a monochromatic aural environment while simultaneously suggesting spatial motion and a sense of stasis, achieved through the formal elements listed in the following table. As with other chambers of *Symbiosis*, limiting the palette of sounds supported the impression of an internal sense of consistent timbre in the work. The spectral qualities of this sound fill the audio spectrum in distinct noise bands. When used at different amplitudes, these appear and recede invoking different levels of listener attention. A spectrogram showing several noise band variations appears in Image 10.

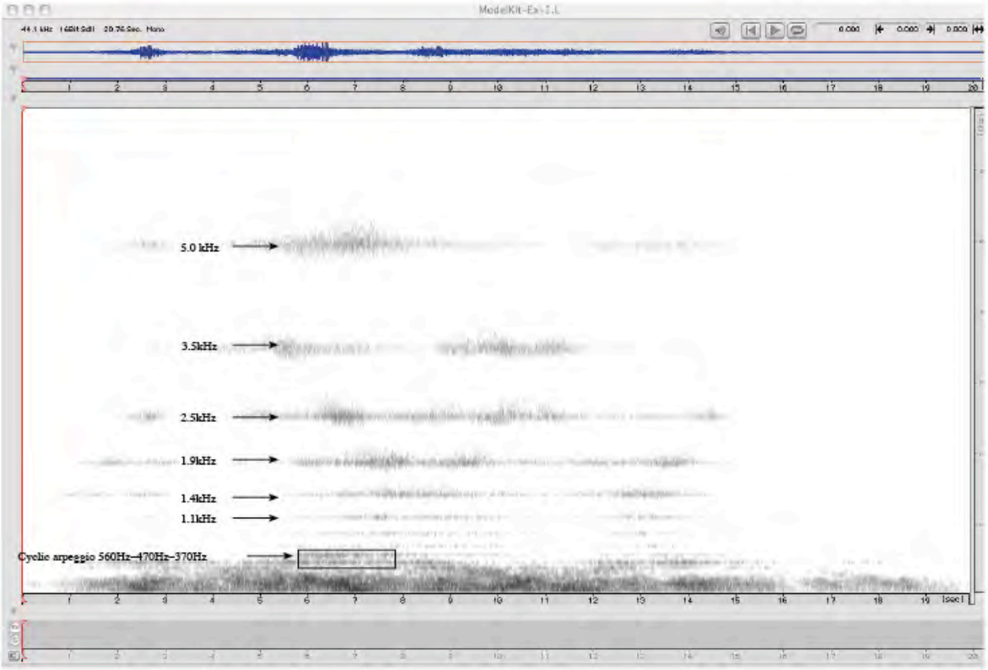

Image 10: Modelkit *spectrogram with highlighted bands of noise band*

The noise bands are predominant around 3.5 kHz, 2.5kHz, 1.9kH, 1.4kH and 1.1kH. The most distinctive band occurs intermittently around 5.0khz, for example at 5 - 8 seconds in the audio example. This high frequency band is filled with a gritty rasping texture. A subtle arpeggio can be heard cycling around 560, 470 and 370hz.

These are all subtle indications to movement by dynamically varying parameters in a sound, as opposed to static state jumping, or juxtaposition of differentiated sound types in the calls of *Nebsphere*. The noise streams appear to flow from, into and through each other. The mosaic of streams spatially overlaps itself in different ways - front back variations, and combinations of variations and channel locations. While the boundaries of the individual mosaic elements are smoothly overlapping, the variations themselves have distinct characteristics – described as 'flutter', 'ascending filter', 'pulsing bass', or 'brittle foreground' sounds. These characteristics allow streams to merge or appear to be segmentations of a single process carved from different sonic layers of the same raw timbral material.

Sound example 6: Modelkit *from* Symbiosis

Construct

Although third in the series, *Construct* was the last soundscape created for *Symbiosis*. The visual environment is primarily comprised of organic forms, scaffold-like constructions and massed scattered geometrical volumes. The temporal dimension of this environment is articulated through the regular appearance of visual details in the environment. These are parts of the virtual model that are being turned on and off with a slow fade, via settings associated with the levels of details (LODs). LODs are usually used to disguise low polygon models and achieve optimum run times, where the effect is to manage fidelity within the constraints of human perception.

In *Construct* the observer appears to be gradually 'walled in' by the environment, but only within the immediate spatial location. The soundscape here is intended to invoke a world associated with assemblage around the listener. Cues for various sonic textures are taken from the main elements described above, in particular, the organic forms and massed scattered volumes.

Construct is the most gestural sounding of all chambers in *Symbiosis*, with sounds that energetically distribute material around the listening space. Sounds invoking construction accumulate and invade the space, in contrast to the gradual developments and subtle shifts of *Landscape*, *Still Life* or *Nebsphere*. The form of *Construct* has the most sections of all *Symbiosis* environments. The seven sections of the final eight-minute piece are detailed in Table 11.

Section	**Description**
1	Opening with gradual fade in of the soundscape, with some construct sounds.
2	Entry of wispy wind modulating sound and pitch change of foreground attention held by construct sounds.
3	Entry for *Canopies* sounds and deep resonant sounds that build to gentle climax before dissolving into 'feedback sound', which becomes bed for next section.
4	Some residual *Canopies* sounds, bed of feedback sound and foreground of 'blob' sound. An unusual moment, as the bed doesn't always occupy just the background.
6	Return of modulating wind sounds and others, some versions of all sounds that have appeared.
7	End descent into silence.

Table 11: Construct *main seven sections*

A tension is established between sounds that conspicuously occupy the foreground of the work, and those that linger in the background, often behind the listener. This creates the distinct spatial qualities of this soundscape. This is not achieved by reverberation, or filtering effects, but through motions between these two aural perspectives, or incursions, creating a combative state as different textures vie for dominance in the soundscape.

A notable example of an incursion from 4:20 occurs, as attacks with similar sound quality permeate the space around listener. The bed throughout this section remains the pointillist 'bouncing' from the previous section. Although made from distinctly different source materials, note the similarity in sounds of opening attacks, main construct sounds and 'blobby' attack sounds of the section commencing at 4:23. As in *Nebsphere*, this similarity supports seamless transitions between states and sections, as sounds appear to share a material provenance. At the start of the main section between 4:24 – 5:25, appears a direct sonic interpretation of the globular construction forming objects. The pre-emptive single appearance of this sound at 3:16 marks the saturation of the soundscape by 4:24.

Sound example 7: Construct *main attack sounds*

Two examples of the opening strident attacks are Sound example 7.1 (Construct-main-attacks-1) and Sound example 7.2 (Construct-main-attacks-2). Sound example 7.3 Construct-Cellophane_GlassAttack was made by cross-synthesis and to achieve a smearing of the sound that maintains textural consistency with the main attack sounds. It was used in Construct *to link disparate versions of the main gestural attack sounds or extend their presence. Sound example 7.4 (Construct-attacks_4_20), is the source file for the section between 4:24 and 5:25, as discussed above. Sound example 7.5 (Construct-bouncing_signals), appears just before this main section and continues as a 'bed' for the following section. The final Sound example 7.6 (Coin-plate-2) is the source file for the attack sounds. It is an Australian 20 cent piece spun on a metal serving plate.*

Sound example 8: Construct from Symbiosis

Still Life

The visual qualities of this chamber are striking. It is clearly an immense space, with a sense of floating inside a large spherical chamber. While it appears the atmospheric state of the chamber is aerial, a shimmering effect suggests either other substances may fill the chamber, or perhaps it comprises a denser material hovering between the materiality of air and liquid.

Sounds recorded in air and underwater are the basis for the soundscape of this chamber. The underwater sounds were adopted from an earlier project recorded with hydrophones (underwater microphones). The original recordings have been time-stretched, revealing breath-like rushes of air exhibiting a fluid pulsing motion. Other source material includes processed dripping sounds originally recorded in an ocean cave at Rye Backbeach, just outside of Melbourne.

Sound example 9: Still Life *breath cycle & descending textures*

The inhalation-exhalation cycle made from a time-stretched breath cycle can be heard in Sound example 9.1 (Still_Life_breath cycle). Two versions of the descending Risset Tones can be heard in Sound example 9.2 (Still_Life_Descending texture_1) and Sound example 9.3 (Still_Life_Descending texture_2).

The inhalation-exhalation cycle is the formal device for the soundscape of this chamber, making one long movement with no dramatic or major changes, nor distinct sections that would indicate a significant change of state. It is a contraction and expansion of a single texture. A sense of ever-present motion is conveyed through the cycle of inhalation–exhalation sounds time-stretched forty-fourseconds duration. The low frequency range occupied by the sound also suggests that it emanates from a large being. During the eight minutes, a secondary cycle temporarily appears to overwhelm the foreground of the listening environment, then recede, almost disappearing as other sounds occupy more prominent locations.

The episodic appearance of infinitely descending textures, or Risset Tones, invokes a sense of motion through the largeness of the cavity, being a set of downward trajectories falling through the void (see Sound example 9). However, on careful listening, the foreground is also occupied by soft ornate events. Although it appears to be one long fade in, there are smaller faster changes within the textures, for example, pitch changes of Risset Tones, and drips of water. Some elements like the drips are continuously present through the whole soundscape, always just below the foundation sounds, creating a disturbed surface. Beginnings and ends of cycles in *Still Life* are never clearly delineated, the fades are long and once again textures appear to dissolve in and out of each other.

Sound example 10: Still Life *from* Symbiosis

Backface

The effects of volumetric dimensions, geometry and material qualities on sound within a space are usually interpreted as reverberation. The role of the gongs in *Backface* is one of space filling, a role usually associated with quality of reverberation or what might be called the auditory colour of the space. At all times in *Backface*, the gongs are present around the listener. To sustain this role without repeating the same sound, yet maintaining a consistency to texture, the gongs are transformed in a number of ways, and often in combinations as detailed in Table 12 and Sound example 11.

Transformation	Processing types applied to gong sounds
1	Extreme time stretching is used to achieve a texture forming sounds
2	Moving filter – a notch filter is moved through one of the stretched versions
3	Resonator – to provide low pitched details of the sounds
4	Stereo processing or rapid modulation to disrupt the staid/static materiality of the original sound, as if the whole object has been shaken into the oscillation, suggesting a greater force than this sound is present in the environment

Table 12: Backface *types of transformation of gong sounds*

Sound example 11: Backface *gong transformations*

Sound example 11.1 (Backface_Gong_Stretch) is a gong sample stretched to 60 seconds as per Transformation *1 in Table 12. The attack portion of the original file has been maintained. Sound example 11.2 (Backface_gong_filter_1) has a moving filter passed through the gong as it decays (Transformation 2 in Table 12). Sound example 11.3 (Backface_gong_filter_2) is a slightly time-stretched version of Backface_gong_filter_1 (Sound example 11.2) with a slower filter speed. Two examples of the time-stretched gongs processed with the GRM Tools Resonator appear in Sound example 11.4 (Backface_gong_resonator_1) and Sound example 11.5 (Backface_gong_resonator_2). The Sound example 11.6 (Backface_gong_modulation) is a gong sound modulated to produce a transformation often used to articulate the end of a phrase.*

All other sounds in this chamber have the timbral potential of arising or receding into the gong-related sounds. These include the searing metallic timbres, and the breath sounds of the human like figures discussed next. The gritty, scraping sounds are another example of the disruptive foreground sounds.

The chamber of *Backface* is inhabited by a series of motionless human figures, caught in poses of exertion that might be related to exercise, sport or yoga. Their physical presence is marked by a series of rapid breath sounds. While the beginning seconds of these cycles are always heard, in some instances the middle and tails of these cycles are time-stretched, to seamlessly transform these breath sounds into metallic gong sounds. The transformations dissipate the breath sounds back into the metallic streams and gongs, the idea being that a seamless transformation is achieved between the physical presence of the breath and figures and the primary resonant qualities of the environment.

Sound example 12: Backface *breath examples*

In Sound example 12.1 Breath transformations – 1, a series of deep inhalations and exhalations are quickly replaced by a metallic texture, while in Sound example 12.2, the breath sounds are first time-stretched and transformed into the metallic texture prior to the entry of a resonant gong sound.

While the timbral quality of the gongs provides a rich palette of sounds on which to draw, these sounds also provide a regular gesture in the form of a gentle oscillating rhythm to the experience, created by asynchronous pitch shifts and attacks around the listener.

The sense of immersion is also created by an unusual set of auditory conditions. Low sounds usually associated with large, immovable objects appear above and around the listener, not just statically, but also in motion. The remaining formal element of *Backface* is a gradual sensation of descent. From the opening of the piece, the series of processed gongs appears to step down in pitch over the first half of the work. This pitch sequence returns to its opening level at 4:57, although an additional tension is established, as the lower transpositions remain in the texture followed quickly by a short pitch sequence around 5:10 that emphasises this step descent motion.

Sound example 13: Backface *from* Symbiosis

Landscape

Landscape is built from sounds that are contrasts of pitch and timbre. In the domain of pitch, this is a high, or a static-like sound with metallic sheen and gritty, tearing quality, and deep pulsing textures. *Landscape* contains the least amount of material in *Symbiosis*. As it is the final soundscape in the work, this reduction of material indicates a closing of the series.

The deep pulsing sounds from the opening of *Landscape* appear in different forms and have the effect, neither of establishing a ground, nor foundation sound, but of destabilising any sense of a static sonic environment through subtle shifts in spatial position and texture. There is, throughout this work, a feeling of menace or prescient anxiety but not necessarily danger. In early discussions, Mark Guigliemetti, who designed this chamber, discussed how one of the themes explored visually in the work was a critique of the Australian attitude to landscape.

The auditory perspective and other distance cues in *Landscape* suggest an expansive space. There are few high frequencies, general amplitude levels are low, and there is little foreground sound that would suggest to the listener closeness to a source sound. As in *Backface*, the sounds used are space-filling in their presence and spatialised over many loudspeakers, not just contrasted pairs as in *Modelkit*. The physical form of the chambers visited during this journey are circular, a spatial condition echoed through the soundscape via a series of circular paths, as if sounds have been accelerated and ejected around the periphery of these spaces. Other sound transformations such as amplitude modulations are intended to suggest that great pressure is being brought to bear on the materials.

Sound example 14: Bounce sound from Landscape *and amplitude modulations*

From approximately 3:50 of Landscape

The first example of metallic sounds from Landscape *is Sound example 14.1 (Landscape_Metallic_short). Three versions of the high metallic sounds that transforms into a gritty tearing quality are Sound examples 14.2, 14.3 and 14.4 (Landscape_Metallic_to_Granulation_01, Landscape_Metallic_to_Granulation_02 and Landscape_Metallic_to_Granulation_3). The deep pulsing sounds that open and dominate the work appear in two versions in Sound example 14.5 and 14.6 (Landscape_Low_presence_1 and Landscape_Low_presence_2). These two variations contrast in envelope and duration, the first having an attack-decay profile, while the second is arch like but also decays to silence. The attack sound at 6:26 is Sound example 14.7 (Landscape_attack_sound). The tail of this sound was remixed to provide a quasi-circular gesture that suggested the material had been accelerated and ejected around the periphery of the space.*

The work is a single long movement, with no discernable sections. Events that might indicate a clear beginning through a gesture gradually dissipate into the primary sounds of the environment. The sense of immersion in *Backface* is revisited in *Landscape* through a brief appearance of sounds from *Backface* ca. 5:00 - 5:10. The only other distinguishing feature of the *Landscape* is the attack sound at 6:26. It is prepared through an extended static section from around 5:00 - 5:30. The rhythm of the work slows from around 6:00. In an earlier version of the camera path, this event was synchronised with a small animated figure that appeared in the distance, but as a purely sound event, the attack is intended to reiterate the sense of anxiety, by remaining in the environment but with an unanswered source or impetus for its sounding.

Sound example 15: Landscape *from* Symbiosis

Video example 2: Symbiosis *example of installation*

This video shows examples from the original Symbiosis *exhibition. The video was originally made for promotional purposes and for exhibition negotiations and shows members of Metraform interacting with the work. Video used with permission from Metraform.*

2.3 Canopies: concert version

Canopies: concert version is a two-channel electroacoustic music composition for live sound diffusion over multiple loudspeakers. The palette of material from which *Canopies* was made, was borrowed from the original *Canopies* installation, however, some material is extended through additional processing to embed certain spatial qualities in the timbre of the sounds. The form of the work is derived from the idea of traversing different environments, as one might in the original installation on successive visits to a site. The duration of the work is 12 minutes and 15 seconds.

In 2000, I was invited by Curtis Roads to submit a work for the *Organized Sound* concert at CREATE, University of Santa Barbara.[57] The work was premiered in a concert on Thursday 17th of May 2001, in the Lotte Lehmann Concert Hall. Besides the motivating factors of an invitation and a deadline, the work was composed for two other reasons. The first was to explore a compositional approach that would produce a work suitable for a sound diffusion system, and the second, was to revisit the material of the original *Canopies* installation, in a highly focussed way. I worked on the concert realisation of *Canopies* over the summer and early part of 2001 in my home studio, using a G3 Macintosh, Pro Tools, and a small set of sound processing software packages: Soundhack[58], Hyperprism[59] and GRM Tools[60].

The organisation of the original installation using timbre sets was carried through to the concert version, which is also based on distinct timbre groupings. Not all timbre groupings from the original installation appeared in the concert version for reasons of duration and quantity of material. Where the installation had a cyclic structure unfolding over a three-month period, the concert work was to be around fifteen minutes duration. In Sound example 17, the timbre sections are marked.

The expected listening conditions and presentation technologies for the concert work also influenced its making. The acoustics of interior spaces or concert hall listening conditions would most likely have little or no background noise, and the loudspeakers would ideally be of better quality, as compared to the urban soundscape system of the original installation. This meant that a level of finer detail could be introduced into the sounds, which I discuss later as embedded spatiality. This detail or fine crafting of individual sounds and variations occupied by far the most time while making this work. To that end, the composition of the work followed an inside-out approach, starting from fine details, and progressively building ever-larger sections, as opposed to filling in some predetermined durational plan for the work.

The concert version of *Canopies* has four primary sections, in which subsections are embedded. Another link between the installation and concert versions was to be a sense of transition, similar to that of walking through the original multi-channel installation at Southgate. In the subsections, material often overlaps, conforming to the three-layer compositional strategy later discussed, but it also recalls the auditory experience of standing on Southgate, between different zones of the installation loudspeakers so that different proportions

57 Concert details are available at <http://www.create.ucsb.edu/news/organized_170501.html>, viewed July 20, 2006.
58 See <http://www.soundhack.com/>, viewed July 20, 2006.
59 See < http://www.kalimba.com.au/Arboretum%20Hyperprism%20Plug-in.htm>, viewed February 5, 2008.
60 See http://www.grmtools.org/, viewed February 5, 2008.

of timbre sets are heard depending on the proximity of the listener to one zone or another. The transitions between sub-sections are generally gradual while the three transitions between the four primary sections include an abrupt pause of five seconds (sections 1 to 2), a cross-fade of 1 minute 8 seconds (sections 2 to 3) and a 'pitched-bridge' with no pause between the sections (sections 3 to 4).

Start (mm:ss)	**Finish (mm:ss)**	**Duration (mm:ss)**	**Description**
00:00	02:36	02:36	Section 1: opening calls
02:36	02:41	00:05	(Transition: abrupt pause)
02:41	09:00	06:19	Section 2: mix of flurries, wash, metallic storm
09:00	10:08	01:08	(Transition: crossfade)
10:08	10:40	00:32	Section 3: pitched dulcimer calls, spatial counterpoint
10:40	10:40	00:00	(Transition: pitched bridge with no pause)
10:40	12:15	02:35	Section 4: dissolution of metallic pitches to noise streams

Table 13: Canopies *start, end and duration of four main sections*

Section 1 is composed of several of the original 'call' sections from the installation, with additional processing and variations. The intended listening experience of this section is to immediately plunge the listener into a dynamic, chaotic menagerie of clicks, chirps, sweeping tones and pulsing metallic timbres. The processing for the sounds in this section was cross-synthesis in the program *SoundHack.* This process maps spectral attributes from one sound onto another, with sometimes-chaotic results. The short pauses in this section allow contiguous subsections to finish, then start in different locations in the hall, as the sound diffusion operator can quickly change the settings on the mixing desk, and thus the spatial location of the different sections, during the short pause. The modulations and diverse material enhance the spatial motions of sounds in the space, appearing as if energy is applied to the sounds causing them to be projected around the listener. When the spectrally distinct sounds are placed in different loudspeakers, both these affects lead to an illusion that there is more than two source channels of sound being projected around the listener. The combined affect of these compositional elements – pauses, spectrally distinct materials, and modulations – also contributes to the illusion there is more than two source channels of sound.

In section two, the form drives toward a flurry of metallic-like textures and dry bamboo chimes that eventually resolve into noise-like streams of sounds. By the middle of this section around 6:50 - 7:20, the auditory image I am attempting to evoke is the centre of a vortex. In addition to being the halfway mark of *Canopies* and a contrast to the unruly opening section, this subsection is also intended to settle the space for what follows. In the Melbourne performances, I started the descent of this section from 2:49 in the speaker-trees – small loudspeakers on stands positioned over the audience – and gradually faded-in loudspeakers around the audience, until the middle noise streams at 6:50 enveloped the audience with a rush of wind-like timbres. The final part before the transition between section two and three at 9:00, also pre-empts the final ephemeral tones of the work, which approach an almost 'timbreless'-

like state. The diffusion strategy I have used for this section is much slower and subtle. Small changes between groups of loudspeakers, some at extreme locations create a sense of envelopment around the audience.

The prescient state of Section 2 is resolved by 10:08, with a texture I think of as a single 'species' invasion. These sounds were attentively crafted for the purpose of imbuing a strong sense of agency, or release of energy linked to their presence in the space. The source sounds were created from vocal improvisation created in the *AudioMulch*[61] environment, then individually crafted with unique dynamics and slight de-tunings. The density of organisation, and small pitch shifts applied to these sounds were derived from my own listening to local Bellbird colonies[62]. A short example of a Bellbird colony appears in Sound example 16. The start and stop of each 'call' is distinct in the stereo mix, setting up static and dynamic fader groups in performance means the calls appear to move through themselves. I was not aiming to directly imitate the Bellbird calls, but rather, I was more interested in a listening and reading of the spatial organisation and qualities of the individual birdcalls with the overall textural mass. Individual sounds in this section have three parts:

- attack articulation marking the starting location and gesture of energy release
- body or travel component tracing a trajectory through space
- end gesture, as a conductor's hand might make through space, or the depart–fly-arrive of an individual bird

The small pitch shift applied to each sound increase the amount of aural information for the listener. As not every sound is identical to its immediate neighbours, the effect is intended to register quick but subtle differences in consecutive calls. This section moves immediately to the final section with no transition. A dyad, or two-tone chord of frequencies 400 and 600 Hz, has been subtly present in sounds from 9:00 and it is this pitched texture that is carried over, somewhat like the suspension of classic species counterpoint with the effect that solid, gestural territory has dissolved or evaporated (from 10:40) into a texture-like material that establishes a stronger sense of expansiveness in the spatial impressions of the sounds.

Sound example 16: Bellbird colony

This short example was recorded in bushland 10 kms from central Melbourne. The original recording format was ambisonic however, this example has been decoded to stereo. The example illustrates the timing, spatial composition and pitch organisation of a Bellbird colony that influenced the main gesture discussed in this section.

Sound example 17: Canopies: concert version

61 A sound processing software environment created by Ross Bencina, see <http://www.audiomulch.com/>, viewed August 15, 2006.
62 The Bellbird is remarkable for the high-pitched piercing tone it can produce. The effect is even more pronounced as the birds congregate in large colonies marked by a continual calling between members.

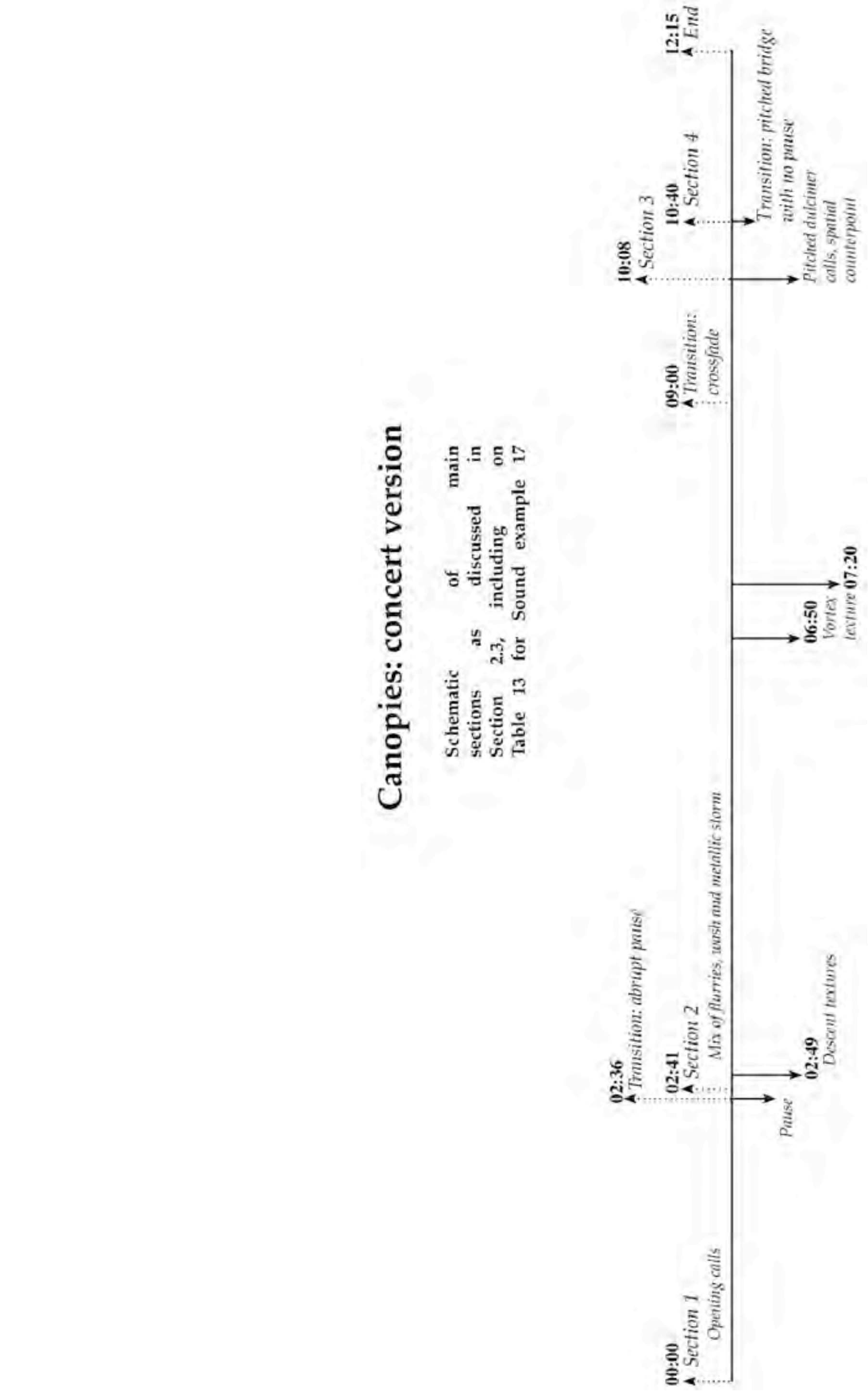

Figure 4: Canopies: concert version *structure*

This figure shows the main sections and descriptive terms for those sections as discussed in Section 2.3 *Canopies: concert version*.

2.4 Ecstasis

Ecstasis was a multi-user audio-visual installation, which involves up to four participants who simultaneously explore the virtual environment via a multi-user head-tracking system. Motion through the work is determined not only by an individual's decisions on where to move within the environment but also by the sum of the activities of all participants. The work is projected onto a large semi-circular screen with blended video output from six separate projectors producing a stereoscopic 3D screen 7.8 metres wide and combined with an eight channel three-dimensional sound field. The sound design is based on a cyclic structure that repeats around 20 - 30 minutes.

Ecstasis is the largest, most extended interactive work I have made to date. It draws substantially on the experiences, skills and knowledge gained in *Symbiosis*, *K* and *Canopies*. Where early stages of making in *Canopies* and *Symbiosis* were intensely occupied with recording and processing of sounds as material, *Ecstasis* commenced with a long period of software development critical to enabling the type of spatial sound design I envisioned for this work. *Ecstasis* was to progress from the pre-rendered sound design of *Symbiosis* to real-time modulation of sound material.

During *Symbiosis*, the limited audio capacity of virtual reality systems was a critical design constraint. It was as if the last 15 years of computer music, sound transformation and processing had little impact on sound design for virtual reality systems. The Max/MSP environment described here was an attempt to bring some of these technological advances to a virtual reality platform. The design and aspirations for the *Ecstasis* environment were ambitious in terms of the data coupling between the visual, audio and interaction devices. What was achieved was the successful integration of examples of all original conceptions, and identification of future directions, particularly around auditory envelopment and spatial synthesis for my work.

My experience of *Canopies* also informed *Ecstasis* through attention to temporal organisation and more sophisticated control of sound processes via data streams. Early in the *Ecstasis* project I aimed to make the project generalised enough that other works such as *Canopies* could be remounted using the same software environment. While this has not yet occurred, concepts and many Max/MSP objects from the *Ecstasis* project have been used in the SIAL Sound Studio diffusion control project discussed in Chapter 6.

Ecstasis is described here through its main elements grouped into five sections. As the project was funded after an extensive application process, significant conceptual details were developed and documented by the collaborative team prior to the commencement of production. This is described in *Background and beginning to the project.* Data generation and control were a significant component of this project and realised through a large Max/MSP patch I developed for the installation. The real-time control of the work and complex sound transformations meant the notion of the datascape and its three layers assumed central importance and are detailed in *Three layers of the datascape.* As in my other projects, the importance of audio source material as a design element has a central place and is dealt with as the third section. In *Processing and spatialising processing,* I describe the mixing paradigm implemented for *Ecstasis* to create layers of sound in static and dynamic arrangements from different stages in processing chains. The fifth section, *Other significant project design elements* contains brief discussions on components of the Max patch developed to successfully mount the work as a stand alone gallery installation. The need for these components or modules arose as production on *Ecstasis* unfolded and are included in this discussion to exemplify the scope of the software platform required to deliver a polyphonic, multi-channel, real-time spatialised sound installation.

Background and beginning to the project

Just prior to the premiere showings of *Symbiosis* for the Melbourne International Film Festival in July 2001, *Metraform* received funding from the Digital Media Fund of Film Victoria to produce *Ecstasis: human presence in digital environments*. The application process required considerable details of conceptual, project management, financial and technical aspects of the intended work. The requirements of tracking and reporting on substantial Victorian State Government funding meant the documentation of *Ecstasis* is extensive. The project was subject to three formal milestone presentations and accompanying written reports on successful outcomes in artistic, technical and financial areas as a condition of the next milestone payment. The production phases of the project were preceded by a formal contract and closed with an extensive acquittal report. The project spans the period from the funding application in May - June of 2001, to the final audio production session of the first version between July 13 - 15, 2003. Other significant work periods occurred just prior to exhibitions, and also in early 2004, when the whole project was migrated to the new Macintosh OS X operating system.[63]

One consequence of *Symbiosis* that influenced the making of *Ecstasis* was the decision to develop a new approach to delivery of spatial audio in the VR Centre using the Max/MSP software environment. I wanted to continue my interest in micro-timbre and sound transformation along with other compositional ideas arising from *Canopies*. My thinking was that to achieve the detailed type of sound design I was interested in would require the simultaneous control of many parameters. For example, the sound-file player discussed later in this section has 24 parameters for continuous and discrete control (see: *An expanded sound file* player on page 116). Although the sound processing in *Ecstasis* is real-time, it uses processing software packages similar to those for the sounds of *Symbiosis* where sounds were pre-processed in studio sessions, recorded, edited, and compiled in ProTools. To properly implement the GRM Tools modules, I wrote an analysis to determine the correct non-linear mappings of input to ouput data used by the modules, which later became part of the final *Ecstasis* data layer.

I realised early in the project that developing a complex sound design over time required a method of moving between different production spaces. Complexity as used here refers to the combination of following attributes:

63 Sections relating to the sound design from the original applications, milestone and acquittal reports have been used in the following project description as primary source material.

- number of simultaneous sounds
- real-time processing of all sounds
- spatialisation of sounds over eight or more loudspeakers
- timing and scheduling of events
- use of combinations of interactive and generative data for simultaneous control of many parameters of the sound field

Portability of the software environment was necessary for three reasons. Firstly, access to the VR Centre was limited as the main room of the facility operated as both presentation and production space and was heavily booked for other projects. Secondly, the acoustic conditions of the VR Centre were extremely poor making fine adjustments to sound very difficult given such deficient listening conditions. My collaborators in *Metraform* and I hoped the work would eventually tour away from the VR Centre with the possibility of hearing the sound design in improved acoustic conditions. This indeed eventuated, with extraordinary acoustic conditions for an extended showing at the Biennial of Electronic Arts Perth (BEAP).[64] The exhibition in Perth included rear-projection effectively removing the most intrusive noise source from the audience area. This was not the case in the VR Centre at RMIT University, where three large projectors were mounted in the ceiling immediately over the central audience area with no acoustic isolation. The ceiling and walls of the BEAP exhibition were packed with acoustic foam, and the purpose-built space had a virtual door isolating other gallery sound from the *Ecstasis* exhibition room. Carpet was also placed on the floor to reduce the reverberation time. The loudspeakers too were purpose-built and of extremely high quality (see Image 11 to Image 13). Thirdly, I had also identified another problem with the physical design of the VR Centre for audio production. Although a small sound studio existed at the VR Centre, it was not possible for a sound designer to view a 3D model and listen to their work on a multi-channel system while working. This is inadequate as the production and delivery environments should be the same, or have a similar number of loudspeakers and spatial configuration of those loudspeakers. As it takes many hours of detailed listening to craft sounds, such a system must also be accessible to the sound designer on a regular basis.

64 Biennial of Electronic Arts Perth. A special acknowledgement for the superb acoustic conditions of the installation must be extended to Chris Malcolm and staff of John Curtin Gallery, Curtin University of Technology.

Image 11: Ecstasis *Perth exhibition space during construction*

The curved screen of the VR Centre in Melbourne was substituted here with three flat screens for rear projection. Test joysticks can be seen on the floor in the middle of the image, and front loudspeakers in the cavity under the central screen.

Image 12: Ecstasis *rear of exhibition*

Equipment racks (left image) and wooden units to hold projectors (centre image) at rear of exhibition space. A stack of amplifiers (right image) for front and side loudspeakers. The equipment racks (left image) house the audio computer. The laptop on the stand to the right of this rack was used for development and final changes to the Max /MSP environment. The exhibition computer used Max Runtime, so changes had to be implemented and copied from the laptop to the audio computer.

Image 13: Ecstasis *speaker locations*

Images shows loudspeakers mounted under central screen of the exhibition.

Three layers of the datascape

The three layers of the datascape in *Ecstasis* were generated from user input, algorithmic processes and data from the visual environment, which I referred to as interactive, generative and intra-active layers. Used individually or in combination, the three layers of data are manifest through different sound strategies and control these sound layers in distinct ways. A sound processing module, spatialisation process or sound-file player might receive data to discrete parameters from one or more layers at anytime. Although the subtitle of *Ecstasis* is 'human presence in digital environments' I felt that not all sounds should be directly linked to human action as tracked by the technologies, or resulting from navigational factors such as collisions. In part, this was a response to critical comment from collaborators who noted that early versions of *Ecstasis* lacked the drive or sense of forward motion present in the sound design for *Symbiosis*. Following this, I created the final, third composed layer of the work, which was distinct from the others. The overall conception of the software environment changed considerably during its making, and the following description was formally presented in a PhD progress review in 2003.[65] A diagram showing the data and audio paths of the completed project appears in Figure 5. Two screen shots of the Max patch appear in Figure 6 and Figure 7. As Max patches rarely reveal much of their real potential, the second two figures should be read with reference to the first. To manage 'screen real-estate' issues in such a large patch, I put all the audio modules hidden to the right of the main control window, which was the one usually sitting on the screen. The two parts of the patch – audio and control data – were kept separate, communicating via the Max 'send' and 'receive' objects.

65 Key stages in the development of this patch are further discussed in *Versions, histories and active archiving* on page 141.

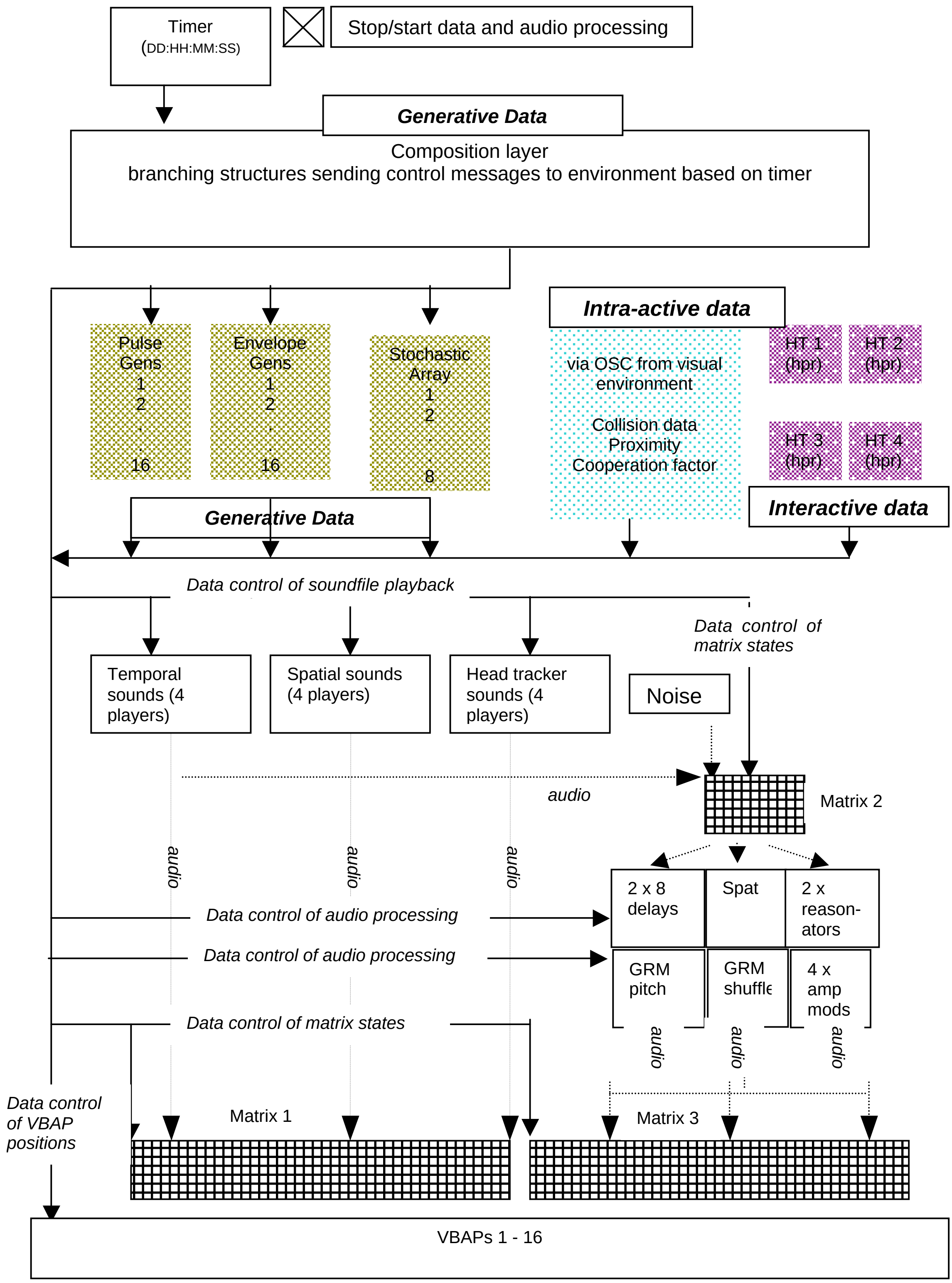

Figure 5: Ecstasis *data and audio schematic*

This figure is a schematic showing how the three data layers could be mapped to any controllable parameter. Audio was generated from the sounfile players, and sent either direct to matrix 1 for spatialisation, or to matrix 2 for processing then matrix 3 for spatialisation.

Figure 6: Ecstasis *control screen – A3 foldout*

This image is a large format screen capture of the control side of the *Ecstasis* Max/MSP environment. This is the final version of the project history shown in *Figure 15*: Ecstasis history of versions – A3 foldout on page 142.

Figure 7: Ecstsasis *audio screen – A3 foldout*

This image is a large format screen capture of the audio side of the Ecstasis *Max/MSP environment.*

Level 1: *Composed layers and data generators – data generated within the Max/MSP environment*

This layer is all data generated solely in the Max/MSP or audio side of *Ecstasis*. It includes the composed layer, pulse generators, envelope generators and stochastic generators, which combined for timing, and simple and complex data for mapping onto and modulating different parameters. The composed layer is described first, followed by the other three types of generator:

The composed layer is a branching structure, where at time-nodes, a branch is selected. There are five separated streams that branch in this layer, where each stream has an independent temporal and branching structure. The composition layer is used to pre-load audio source files into buffers for the sound-file player objects, set starting states for sound-file players, processing modules and VBAP[66] mappings that are then modulated by the other two main data layers. The composition layer was also used to select different mixer states.

66 *VBAP* = Vector Based Amplitude Panning, developed by Ville Pulkki, available from < http://www.acoustics.hut.fi/~ville/>, viewed February 25, 2007.

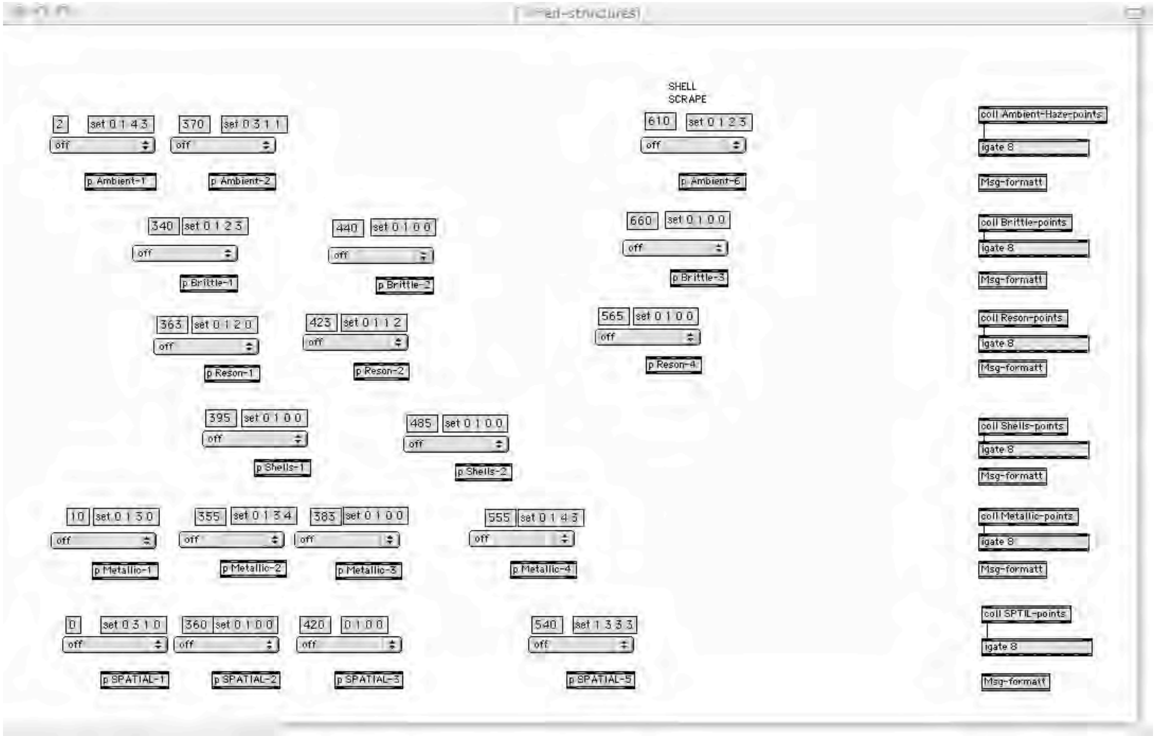

Image 14: Ecstasis *screen capture of branching structure with actual time points*

The composed layer works like a branching compositional structure. It is a branching structure, where time nodes trigger selection to a different branch. There are up to four simultaneous sub-layers in this layer.

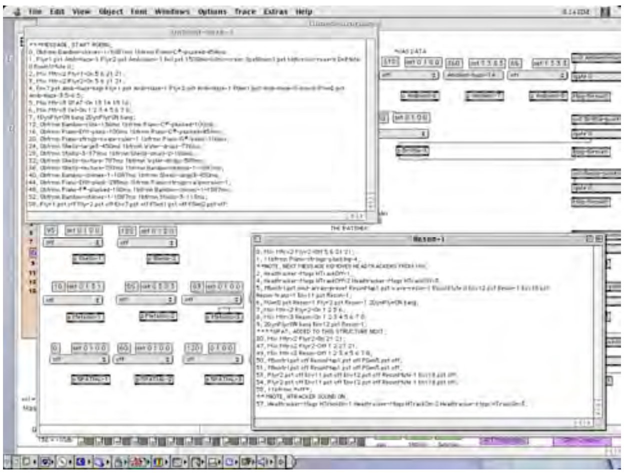

Image 15: Ecstasis *text files at branch points*

At each branch point a quasi-script file with settings for different processes was selected that essentially contained data to set a state for the next section of the cyclic structure.

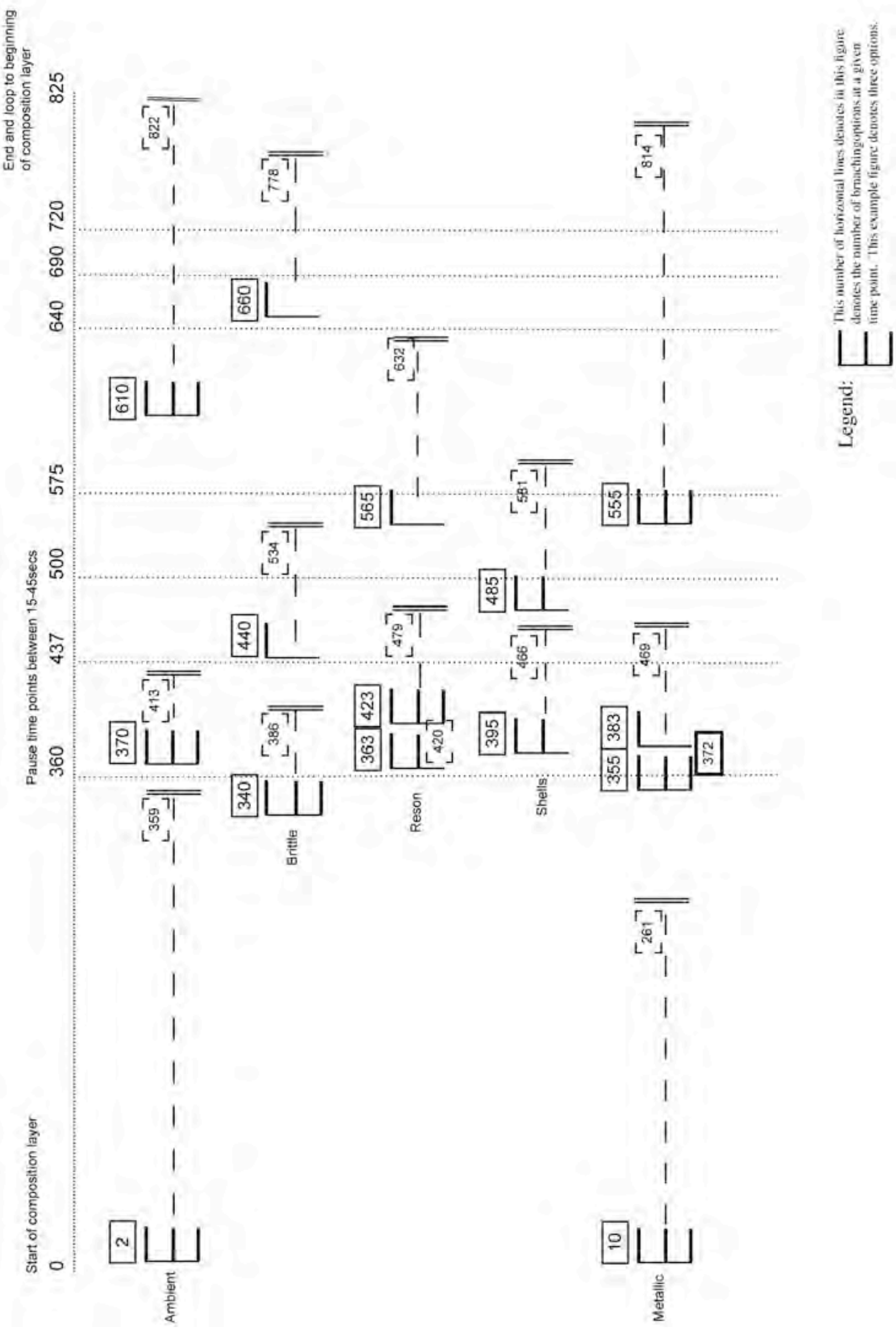

Figure 8: Ecstasis *schematic diagram of branch points*

This schematic is a reduction of the composition layer. The sequence numbers on the top of the schematic are the pause points, where a random duration between 15 seconds and 45 seconds is generated and determines the stop time. The effect of a stop point is to extend a state based on the values at that point. The numbers in solid boxes are the durations for a node and those in dashed boxes are the maximum values for a branch at that time point. This layer commences with high pointillistic sounds in the "ambient" sub layer at top right of image. The rate of activity increases significantly from 340 seconds.

To keep a readily accessible visual record of the timing and branching of the composed layer, I used a line-score technique (where time runs on the horizontal axis of graph paper and sub-layers are distributed down the page) to determine at any point the availability of VBAP channels, sound file players, data generators or audio processing modules. The following image is a scan from the first page of this work document used to develop the final cyclic structure shown in Figure 8.

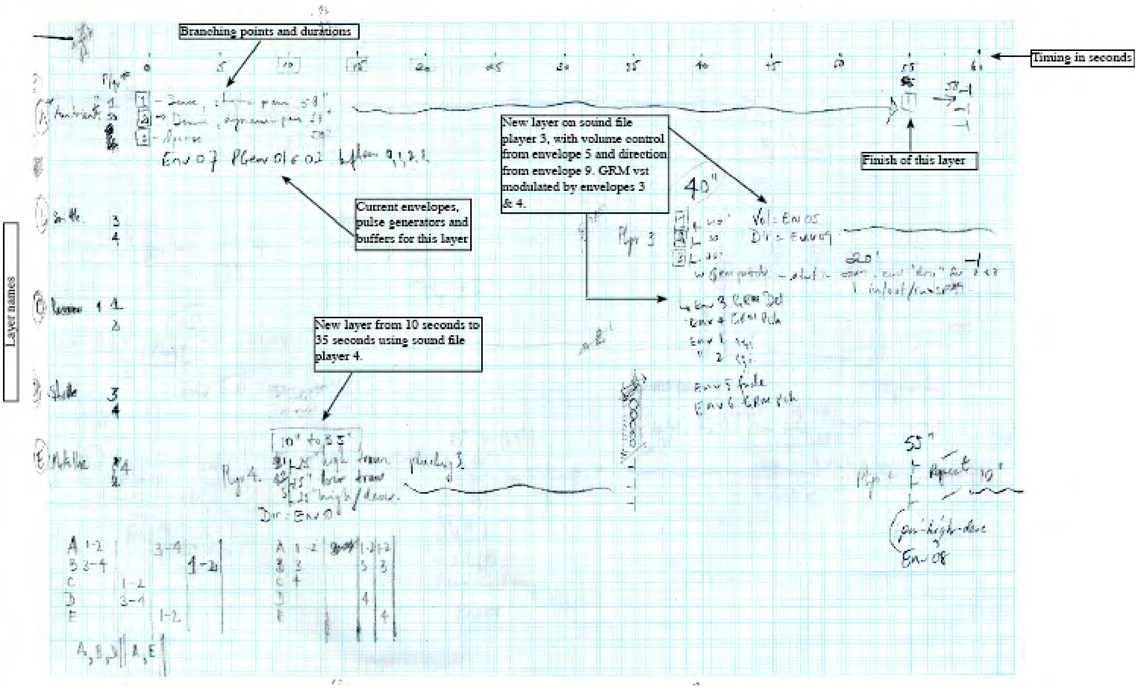

Image 16: Ecstasis *scan of line-score page one*

This image shows the first 60 seconds of the composition layer only. The full cyclic structure is shown in Figure 8.

The composition layer is similar to a musical score with sub-scores. It controls the global state of the software environment, for example; which sound files are playing, the current available audio processing, or assignment of VBAP channels for spatialisation. However, within the global state, indeterminate sub-states exist. The global state might be used to assign sound file players to particular VBAP outputs, but the data controlling those VBAP outputs (azimuth and elevation) might be controlled by stochastic processes, while parameters of the audio processing are controlled via multiple envelope generators.

The *pulse generators* were a wrap[67] of an open source object developed by Karlheinz Essl.[68] The *Ecstasis* environment has 16 pulse generators, which are used to trigger sound files, but can also be mapped to other processes requiring timing, such as the stochastic generators discussed next. Polyhonic textures (literally many voices) could be generated by using a pulse time shorter than the duration of the target sound file along with a polyphonic voice setting of 2 or more. In theory, the system capacity supported between 40 and 120 voices although this was not fully tested in the project.

The *stochastic generators* were a wrap of Peter Castine's commercial objects for generating stochastic processes.[69] There are 8 simultaneous generators available in the system, each able to access around 15 different types of stochastic process. Values are generated on receipt of a bang from the pulse generator objects with the output being mapped and scaled to various parameters elsewhere in the *Ecstasis* environment, for example azimuth and sound file transposition level.

There are 16 *envelope* generators in *Ecstasis.* The envelope x-axis of time can be drawn, and scaled to any time duration from one second to a duration expressed in days, hours minutes and seconds. The y-axis or range of numbers generated by the envelope is set in floating point values allowing finer grains of information to be generated. One reason for implementing long timing options was an intended future use of this module in a soundscape or installation version of the *Ecstasis* software environment, where events or processes could be designed over very long periods of time. Pre-defined envelopes can be recalled and made to start or stop using the MSG-format technique discussed later in this section.

Level 2: *Intra-active – data from the visual environment*

'Intra-active' is a term developed during the project to describe data sent from the visual environment to the audio environment. It may have been triggered through collision detection or proximity of the users to virtual objects. There were great plans for this layer. We spent many weeks investigating whether data points associated with the modulating surfaces could be used to drive elements of the sound environment. The effect was meant to be one of flying through a complex, spatialised mix of an electroacoustic composition. But as the data generators used on the visual platform were sine functions, I found that more dynamic and

67 This term denotes the embedding of a Max/MSP object inside a control structure.
68 For details of Essl's Real Time Composition Library, see <http://www.essl.at/works/rtc.html>, viewed February 25, 2007.
69 Further details are available at <http://www.bek.no/~pcastine/Music/programs.html>, viewed February 25, 2007.

complex data types generated from within Max/MSP were more suitable for modulating audio processing. In part, this is due to the fatigue threshold, or informational redundancy quickly reached if sine functions are used to modulate parameters in sound playback for example, volume or sound processing. The ear quickly resolves the periodicity of a sine function to be annoyingly repetitive. In the final system, the main data sent from the visual environment was proximity to selected objects and positional flags associated with particular spaces were sent from the visual environment to the audio engine.

Level 3: *Interactive – data from the head-trackers*

One of the earliest versions of the project contained a sequence of synthesis algorithms (FM), controlled by head tracker data.[70] While the effect was impressive – reminiscent of a wild guitar solo attached to the smallest changes in head orientation, the sound lacked subtlety. I experimented with many types of mapping on the head-trackers, some revealing themselves as moot settings. For example, a user cannot hear the location of a one-to-one sound mapping of heading-to-azimuth. As the ear relies on the precedence effect to locate sounds in space, this mapping always places the sound directly in front of the immersant, wherever they turn. Whilst other people in the room hear the sound moving, the person controlling it will hear almost no spatialisation.[71] Ultimately, the answer lay in the "less-is-more" category of resolutions. This layer takes the heading, pitch and roll of the head-trackers, and simultaneously maps these streams to timbral parameters and spatial location of a single band of noise fed through a bank of resonators.

Sound example 18: Ecstasis *modulating noise streams in four channels.*

The source sound for this example is a single noise generator sent to a bank of resonators where the parameters of each resonator are mapped to the heading and pitch of individual head-trackers. The output of each resonator is sent to an individual VBAP whose azimuth and elevation is also controlled by the head-trackers. The effect was one of each immersent having a sonic trace of their visual scanning inside the installation. This example is a simulation of the interactive head-tracker layer. All parameter settings at processing and VBAP spatialisation are the same as the real-time installation settings. The data for the example is generated from within MAX to simulate the slow head movements and occasional quick changes of head location.

Audio source material

Recognition of the source sounds in *Ecstasis* is not critical to the experience, however, a brief description of the sources helps describe some features of the final acoustic environment.

70 See section 'Making and Materials', version history diagram for *Ecstasis*.
71 A demonstration developed as part of another project that ran in the VRC for many years used this mapping, much to the perplexed looks of visitors who were told the sound was moving around them.

Many samples were taken from a series of piano sounds recorded using extended performance techniques inside the body of the instrument. The sounds made in this way are subjected to further processing and have a rich resonance and pitched quality imbuing the acoustic environment at times with an instrumental-like quality. Other sources are starkly contrasted to these, and include collections of shells, bamboo chimes, a water gong and wine glass played by rubbing the rim.

I selected sounds that were likely to provide complex sonic textures. In contrast to *Symbiosis* or *Canopies*, the sounds of *Ecstasis* were to be used with little or no prior sound processing, that is, they appear 'dry' and unprocessed in real-time. A part of my working practice is to generate a great deal of material through processing sounds as a way to immerse my auditory imagination in the sound world of the materials. This process is akin to sculpture, or preparatory sketches for a painting, of gradually reducing a mass of material, seeking a shape, a form with malleability that invites further discovery of form. Another analogy is that of the preparatory sketch. Recording, editing and processing the material is another way to test the potential of the materials for embedding in larger composition structures. However, for *Ecstasis,* the final sounding form of the material arose from the three data layers and the ways they controlled the other processing and spatialisation modules of the software environment.

All sounds were recorded at New Market Studios between 10 am and 1 pm on 14th of November 2002 with the assistance of recording engineer Ben Hurt. Image 17 and Image 18 show recording configurations from those sessions where discrete short sounds and longer sequences were captured using close and ambient microphone techniques. At the time, we also experimented with multi-channel recording techniques, although the final versions used in *Ecstasis* were stereo files. During the recording session, we prepared and recorded the piano using an array of screws with and without washers, and small pieces of rubber and plastic. My experience of prepared piano dates back to undergraduate study at the Canberra School of Music in the mid to late 1980s. There, I performed a selection of the *Sonatas and Interludes* of John Cage. For my final graduation concert, I also wrote a work for prepared piano and electronic sounds. To my ear, the sound of the prepared piano was intended to inhabit an auditory territory between the acoustic and electroacoustic world. However, other sounds recorded on the day, together with extended piano performance techniques were finally selected for the composition layer of *Ecstasis*, as the preparations did not benefit the sound world that evolved during the Project’s final production. The piano sounds used most often included plucking on the upper and middle range strings and various swiping gestures using fingernails and a plastic ruler. The prepared piano and recording set-up is shown in Image 18. Other examples of the raw sounds, prior to processing, or with some transformation appear in Sound example 19 and Sound example 21.

Sound example 19: Ecstasis *piano*

The plucked sounds of Sound examples 19.1 and 19.2 (Piano-C#-plucked-100ms and Piano-strings-plucking-4) formed part of the opening pointillist section of the composition layer, along with other sounds, around or less than 1000ms in duration. Sound examples 19.3 and 19.4 (Piano-strngs-swirl-loop1 and Piano-strngs-swipe-ruler-1) were used as textural source material around the middle sections of the composition layer.

Sound example 20: Ecstasis *other pointillistic sounds*

These short sounds edited from longer improvisations on shells, bamboo and water were used in the opening pointillist section of the composition layer. Refer examples 20.1, 20.2, 20.3 and 20.4 (Shells-small-2-186ms, Bamboo-click-136ms, Bamboo-chimes-1-1087ms and Water-drops-776ms).

Sound example 21: Ecstasis *end sounds*

The section just before the loop of the composition layer used sounds from this example. The dramatic attack and resonant tail of the processed water gong in Sound example 21.1 (Water-gong-sftbtr-mod3) can be heard in the Ecstasis *studio recording of Sound example 22. Two other contrasting sounds are provided here in Sound example 21.2 (Glass-smooth-1) Sound example 21.3 (Shell-scrape-1).*

Image 17: Ecstasis *object recoding*

Bamboo chimes and stereo microphones placed to record an even spread of sound between left and right channels. A metal plate for coin recording appears just left of centre. Recording engineer Ben Hurt is shown in the image.

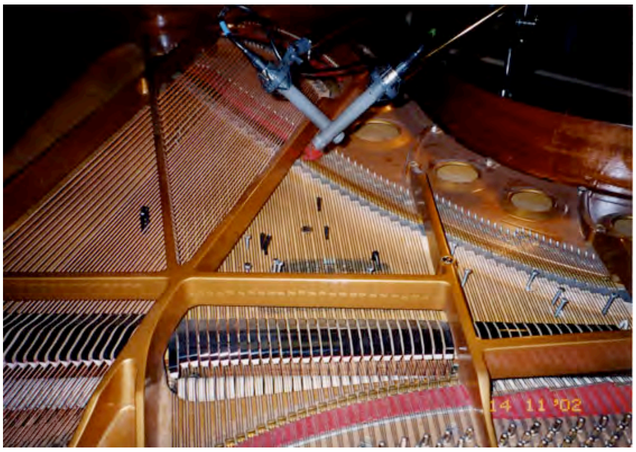

Image 18: Ecstasis *piano recording*

Image of piano interior and preparations with close position microphones. This same set-up was used for recording other gestures inside the instrument such as scraping and plucking strings, played once the preparations were removed.

Processing and spatialising processing

At the start of the Project, I was interested in a process I provisionally called *spatial synthesis* – the close linking of spatialisation to synthesis output channels, especially where a single sound was moving through two or more processes and the outputs from individual processing stages could be spatialised. Perceptually, this was to create situations where the different output stages, or versions of a processed sound could be splayed around the listener. Early in the sequence of *Ecstasis* software versions, there is a stage that shows an experiment where a sound file is subjected to short-time windowing and where individual windows were positioned on unique azimuth locations around the listener (see *Figure 15:* Ecstasis history of versions – A3 foldout, page 143). By the final stages of the Project, the solution was to use processing modules with 1-2 channels in having multiple versions of the same process in parallel, each with an individual output. For example, a single sound could be played into eight resonators, each resonator is controlled with slightly different parameters and the outputs are not mixed back to two channels, but remain separated. The final six processing modules are shown in Table 14 along with figures showing the number of input and output channels per module. The schematic in Figure 9 shows the relationship between sound file player outputs, the processing modules and final outputs.

No. of instances	No. of inputs per unit	Processing type	No. of outputs
2	2	8 point tap delay	8
2	1	IRCAM[72] SPAT[73] modules	4
2	1	8 Resonators	8
4	2	Amplitude modulator	4
1	2	GRM Pitch Accumulator	2
1	2	GRM Shuffle followed by a 2in x 8 point tap delay (delay section has 4 outputs)	2-4

Table 14: Ecstasis *processing units*

For each of the six processing types, the number of instances and the number of inputs and outputs per module. The first four modules have multiple instances to allow parallel sound processing of the same input signal, with different processing parameters and controls, separated to an independent channel for individual spatialisation.

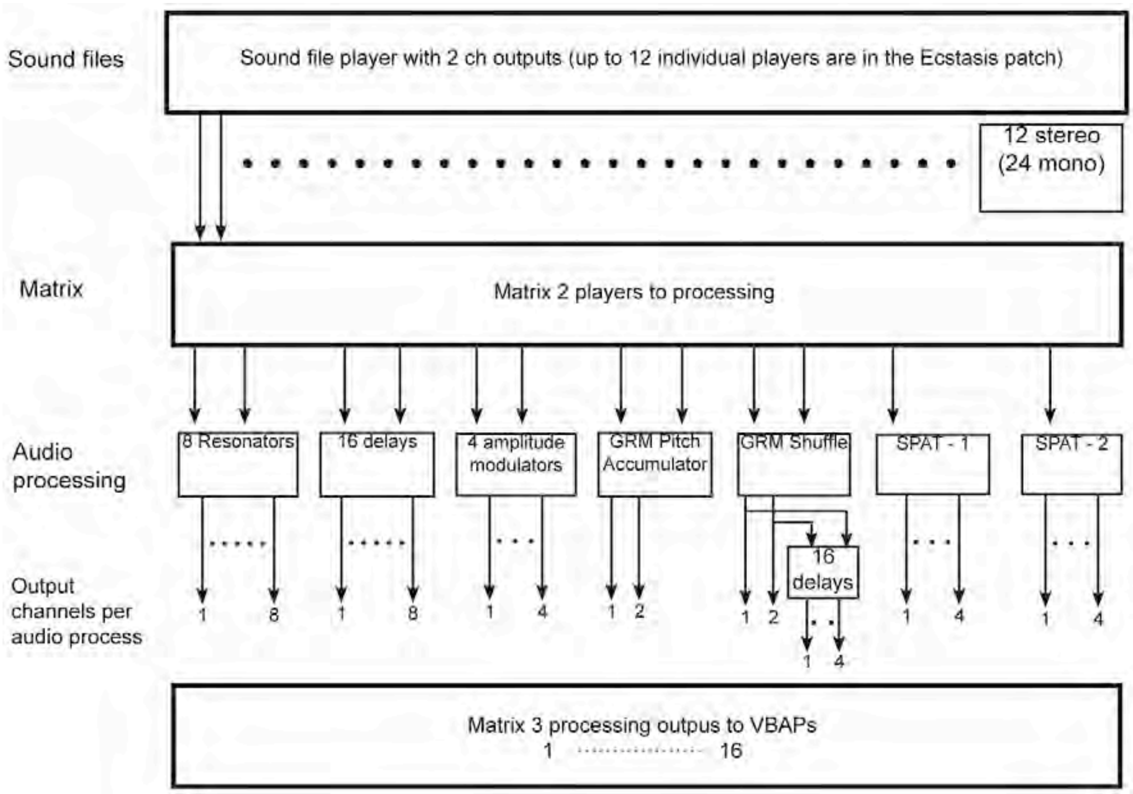

Figure 9: Ecstasis *parameter processing chain*

The source sounds originate from the player section described below. Each process has 1 or 2 inputs but many more outputs. Two SPAT modules were included to allow two different simultaneous reverberation qualities but only one was used in the final work due to CPU stability issues in the OS 9 version of the installation.

72 IRCAM: Institut de Recherche et Coordination Acoustique/Musique
73 SPAT: Spatialisateur. A software package developed at IRCAM for multi-channel reverberation and panning of audio.

As the outputs of individual processing units are separated, they can be patched to individual VBAPs. Where VBAPs share exact spatial coordinates, the sounds will be 'fused' into a single complex timbre. Where enough spatial separation between VBAP streams exist, the streams will be perceived as separate layers. The general sectors I used for static separation in *Ecstasis* are shown in *Figure 23: Ecstasis auditory sectors around a listener* (page 179). In addition to splitting outputs in processing modules, separation is also dependent on the use of matrix mixing. There are three matrices in *Ecstasis* that allow routing of the source and/or processed files to one of three locations the listed signal paths followed:

- Matrix 1: source sound direct to *VBAP*s
- Matrix 2: source to processing modules
- Matrix 3: processing modules to *VBAP*s

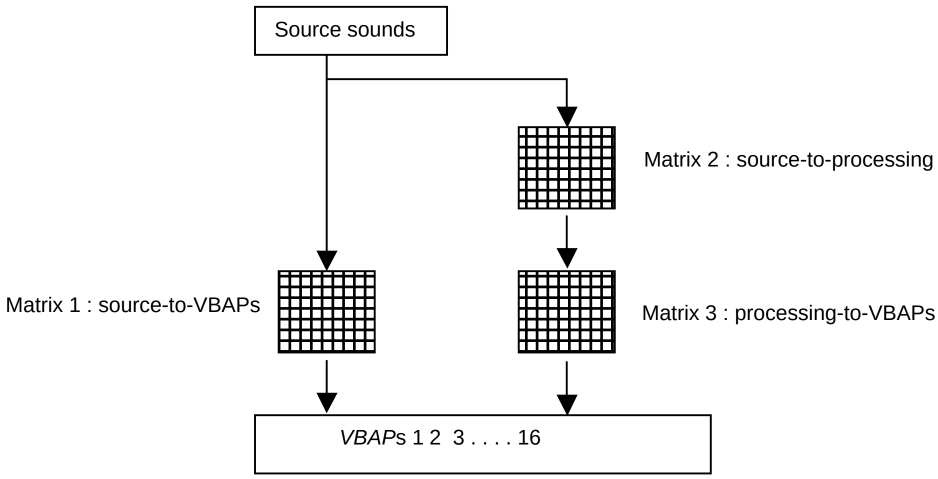

Figure 10: Ecstasis *three matrices chain*

A source sound can be directed directly to the VBAPs via Matrix 1, to the processing modules via Matrix 2, and from the processing modules to the VBAPs via Matrix 3.

With this configuration, a single sound source for example,. a piano sample, can be treated in the following scenarios:

- A stereo source sound is sent to *VBAP* 1 and 2.
- The same stereo source sound is sent to processing then sent to *VBAP* 1 and 2. These two *VBAP*s then contain a mix of 'dry' and processed sound.
- Or, the processed version could be sent to *VBAP* 3 and 4, which might be given the same spatial parameters as *VBAP* 1 and 2 thus producing a mix of the original and processed versions, or if *VBAP* 3 and 4 have unique spatial coordinates, then the spatial

sound design contains dry and processed versions, which might oscillate between the equivalent and different spatial coordinates for the same sound, a scenario where the original and processed versions appear to fracture and fuse over time and spatial position.

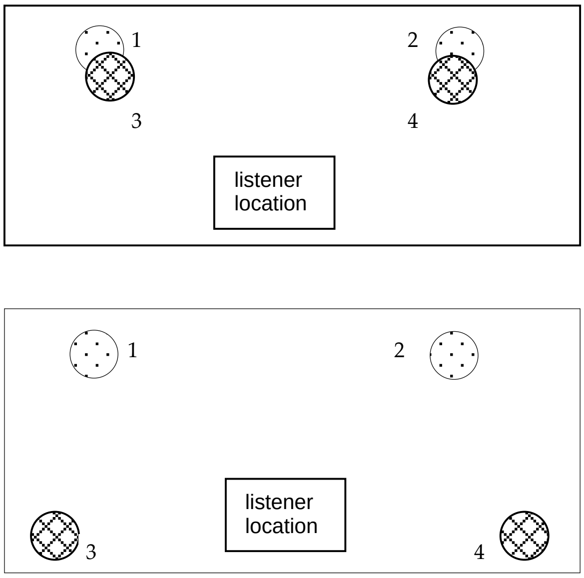

Figure 11: Ecstasis *spatial mixing scenarios*

In the upper box VBAP 1 and 2, represented by dot-filled circles are co-located with VBAP 3 and 4, cross-hatched circles. This is perceived as a mix of source and processed sound. In the lower box, the two groups have split, allowing the listener to spatially locate the two groups as separate, but possibly related sound sources.

Another possibility raised by this system configuration is embedded spatial strategies, which mainly take the form of simultaneous use of statically positioned sounds embedded in moving ones. The nature and significance of this is discussed further in section 3.2. This might include the output of SPAT reverberation panned to virtual source locations above the audience, another eight VBAPs assigned around the audience with output from six tap delays and the four remaining VBAPs being dynamically modulated by a data layer.

Other significant project design elements

An expanded sound file player

Consider a simple way of playing an audio file stored on a computer using iTunes. It is possible to select a file, start, pause or stop the file, and manipulate its playback volume. Again in iTunes, it is possible to determine a library of sounds in a specific order, or let the computer make a random selection from a given pool of files. The expanded soundfile player in *Ecstasis* is a highly charged 'super-player'. There are twenty-four parameters associated with each polyphonic player. There are twelve players in the final system, each capable of playing up to ten instances of a sound.[74] Having decided early in the project, that the sound palette would be built from recorded sounds to achieve a better complexity of source material, the task of building a robust and flexible sound file player became necessary. The diagram here shows each of the twenty-four parameters of the file player.

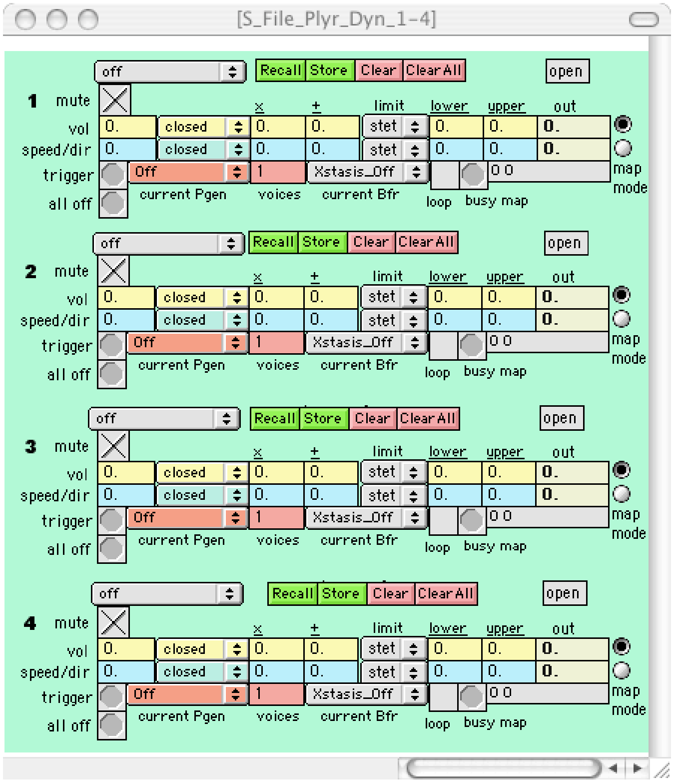

Image 19: Ecstasis *window of four soundfile players*

The final software environment had three windows of four players each. Each of the three windows was assigned to one of the data layers of the environment.

74 In theory, this would mean up to 120 sounds could be played at once. The system was never load tested to this capacity. As an example for the density this would have created, consider that a standard symphony orchestra has 80-100 players, many of whom are duplicating the notes played by others on the same instrument with more or less loudness, but with subtle timing differences.

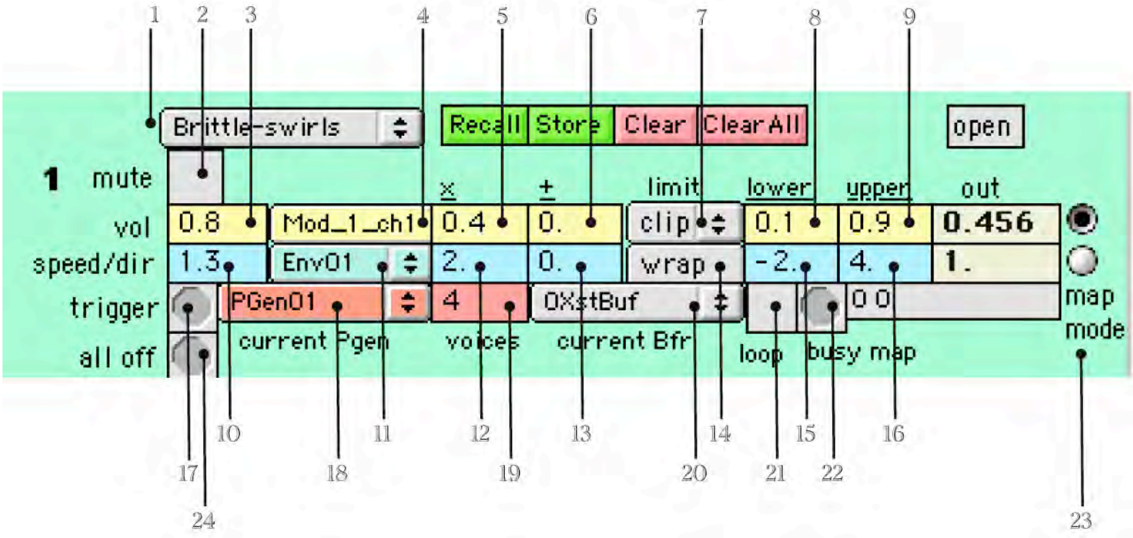

Image 20: Ecstasis *single player*

The numbers indicate the 24 parameters of a single player as described Table 15.

One of the main components of the players is 'current Bfr' (parameter 20 in Image 20), which is the actual sound file to be played. The *Ecstasis* software environment could hold up to 32 sound files depending on total duration of the file and available RAM. The other main components are volume and the mapping parameters to modulate volume indicated as parameters 3 - 9, and speed/dir (direction) indicated as parameters 10 - 16. The data source for these volume and speed were selected in parameters 4 and 11 respectively, and could be from any data generated by the *Ecstasis* environment, read from the visual environment, or from the headtrackers. Sound files were triggered by pulses from the 'Pgen' module selected by parameter 18, or from collision detection messages generated from the visual environment. That is, a file could play on collision with a predetermined visual object. The pulse determines the rhythm in which a file is played while the 'voices' parameter (parameter 19) determines the polyphonic voice setting or number of instances of a file that could be played simultaneously. The player uses the poly~ object of MSP for this function. Complex sound transformations could be rendered by using radical data, generated for example, by the stochastic modules and targeted to the volume and speed/dir parameters, particularly if the player had a polyphonic setting of two or more voices.

	Parameter name	Description
1	Preset	Stores and recalls all settings for this player including mute and all data receives to open with their starting states and mappings
2	Mute	Audio mute only, parameters remain 'open' and receiving data
3	Vol	0 to 1.0, can be stored in preset or set manually for testing
4	Vol Data source	Set data channel on which to receive data
5	Vol x	Multiply the data from Vol Data Source by this value
6	Vol +	Offset the data from Vol Data Source by this value
7	Vol limit	Set method to Vol limit data
8	Vol lower	Set lower limit of Vol Data Source to this value
9	Vol upper	Set upper limit of Vol Data Source to this value
10	Speed	0 + or –1.0, 0 to 1.0, can be stored in preset or set manually for testing
11	Speed Data source	Set data channel on which to receive data
12	Speed x	Multiply the data from Speed Data Source by this value
13	Speed +	Offset the data from Speed Data Source by this value
14	Speed limit	Set method to Speed limit data
15	Speed lower	Set lower limit of Speed Data Source to this value
16	Speed upper	Set upper limit of Speed Data Source to this value
17	Trigger	Bang button for manual testing
18	Pulse generator	Select list of pulses to trigger this player
19	No. of voices	Set the polyphony of the player between 1 and 10
20	Current buffer	Select a buffer at which to 'point' the player
21	Loop	Set player sound file to loop
22	Busy Map	Bang button for manual generation of a 'busy' map to see how many voices are playing
23	Map Mode	Specify either input-output ranges or scale-offset
24	All off	Turn off all voices for this player both manual and automated

Table 15: Ecstasis *list of parameters and descriptions for one player*

The preset at the top of the player stores all the settings for this individual player. The composition layer described above sends out messages to recall the global state for this player's individual parameters, a command similar to an instrumental performer making an entry for a new section in a musical composition.

Stability, efficiency and muting

As the final version of *Ecstasis* had to be a stand-alone gallery exhibition, stability or reliability were critical issues to be resolved. CPU in Max/MSP can be quickly taxed if audio processes are not properly controlled and scheduled, so muting of audio chains was used extensively throughout the environment. At key development times, I ran tests to determine which processes might be using too much CPU. The final *Ecstasis* environment operating on a G4 laptop 1.5 Ghz PowerPC with 1-gig of RAM requires about 12% of CPU on start-up. Following load testing, I determined that the CPU should never be greater than around 45%, which required that all audio processors in *Ecstasis* be enabled for muting in real-time, which removes an audio from the sound-field of the work, and also stops the CPU calculating the samples of that sound-field. *Ecstasis* was installed at the John Curtin Gallery, Perth and the State Library of Victoria, Melbourne for over three months with no major audio technical faults.

Portability

The environment had to support development and pre-production in different work locations. As discussed in the *Symbiosis* project description, the audio production spaces of the VR Centre were basic, so the environment had to be useable in a two channel home studio, with headphones, a four-speaker system, or the eight-channel system of the VR Centre, and finally, more loudspeakers in a gallery installation. For development of spatialisation in these different configurations, I determined that the *VBAP*[75] object was the best solution, for which I developed a wrap for the final version with 16 *VBAP*s in parallel.

Memory module, sending messages and script files

Once the Project began to grow to a significant size, I realised the memory preset object in Max was not sufficiently stable to ensure data integrity was maintained while moving the Project between computers. Furthermore, during the development phase of the Project, modules were often cut and pasted between different versions, which meant preset or system state data was lost. The memory module is based around the 'Multiple Module Coll Memory System' devised by Stephen Kay for storing data in the *coll* object. The implemented memory module holds up to 32 presets for a collection of parameters from an object, or patch. I modified this so that on receiving the name of a preset, the preset would load and initialise the process, so that messages could be scripted and transmitted around the system to stop and start various processes either in response to simulation time, or some other trigger or condition of the external visual environment or the audio environment. The *MSG-format* object I developed supported the composition layer. A coll object could be used like a 'master score file', sending messages around the system at timed points, or conceivably, on some other state condition and associated flags or triggers. This removed the need to declare a 'send' for any and all 'receives'. Instead, on making a new module the *receive* objects for that object were part of the object, or patch, and these could be addressed later from a script coll. The system was very fast, so that

75 Vector Based Amplitude Panning. A technique and associated Masx/MSP objects for controlling multichannel 3D sound developed by Ville Pulkki. From http://www.acoustics.hut.fi/~ville/, viewed 4 September, 2008.

during actual sound design development, only short messages were sent to make significant changes to the environment without disrupting the audio.

The process of production requires ideal states and conditions of the system to be stored and recalled in real-time. Even if the processes are random, or quasi-random, there are starting conditions and stopping conditions to be recalled against some external factor for example, simulation time, actual time, or user input. As every data or audio section of *Ecstasis* has the same memory module recall system, it was possible to send global changes to the whole system via groups of related messages, local changes via individual messages, or groups of local changes by groups of individual messages. Transitions between states in *Ecstasis* are perceived as gradual and without obvious jolts to the soundscape. In part, the memory module-recall method of local changes and the use of fade ramps and muting of sound processors along with mixer messages achieve these seamless transitions. Discrete elements of the state of the software, and individual, whole, or subgroups of layers, can be altered while a bridging part of the sound-field remains.

Mixer messages and mixer states

I developed a method for changing the state of the three mixer matrices either globally, that is, all cells change, or locally, where discrete cells change. This signified that processes could overlap, or change states asynchronously. Otherwise, to change the global state of a matrix object, which is actually a mix state meant undue disruption to the sound, even if the ramp time was set to a long ramp time for example, 4000 ms. Using the cross-fade function of the matrix object, the currently playing sounds would fade out, then in again, creating an unwarranted change in the overall soundscape.

Sound example 22: Ecstasis *studio recording*

This recoding was made of a single pass of the composition layer of Ecstasis*. The headtracker sounds and several instances of the collision sounds have been overlayed to provide an indicative example of how the soundscape was heard in the installation.*

Video example 3: Ecstasis *video of exhibition*

2.5 *K*

Work on *Ecstasis* was partially suspended for approximately eight weeks in 2002 in favour of the *not yet its difficult* (*NYID*) project *K*, an adaption of Kafka's *The Trial*.[76] The Project was a close collaboration with *NYID* and most particularly, director David Pledger. In this adaptation, the political system that entraps *K* is a contemporary corporate environment of free market economics and strategic marketing. The theatrical space is dominated by the spatial sound design through the notion of an acoustic set, designed to entrap the main protagonist in a system of psychological control. As with *Ecstasis*, successful delivery of the Project relied on a Max/MSP environment I had developed during the production. The final version of the work was based on three quadraphonic systems positioned around the audience. The performance duration was around 1 hour 15 mins.

A significant aspect of *K* in the overall output of *NYID* is the use of a fully developed script. The Company's productions are predominately physical theatre and based on strong political and social commentary. The description of *K* from *NYID's* website is as follows:

> Inspired by contemporary events and refracted through Franz Kafka's The Trial, *not yet it's difficult* decodes the matrix of technology and society. *K* fuses hard-core physical action, digital technology, sonic architectures and new texts to portray the dark, humorous and violent world of democracy in the Information Age. Part social realism, part science fiction, part fable, part documentary, *K* lays bare our fragile social apparatus in a hyper-real tsunami of savage absurdism.[77]

NYID's process of creating work arises out of intense collaboration in the rehearsal space, evolving fertile demands as all company members, technical, production and performance, must remain flexible. Changes that are large and complicated or small and easy to implement are suggested, tested, modified, integrated or rejected to shape the emerging form of the show. The sound design and Max/MSP software environment had to enable new material to be inserted into the palette on a rehearsal-by-rehearsal basis. An equal, flexible and prompt collaborative role for the sound designer would have been extremely difficult if not impossible with media such as mini-disk or CD. The software solution allowed me to make changes and keep parallel to the script and rehearsal process of the evolving work.

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76 The break between projects was not a clean one. My diary notes through August and September 2002 show interleaved times for K and *Ecstasis* related meetings, studio work, rehearsals and software development.
77 From <http://www.notyet.com.au/nyid.html>, viewed March 16, 2006.

The criteria for the software environment identified in early production meetings were:

- enable changes to be quickly and easily made and tested in response to demands from technical issues or creative ideas;
- the technical and conceptual challenges to create an acoustic set and the impact on writing & directorial aspects of thinking about sound in this way,
- developing a choreography of sound as a fundamental element to spatial composition and eventually, audience experience of a theatre production,
- sound design as 'score' where interventions into performance are achieved with a flexible mode of interactivity, have a high degree of mobility in text and against physical actions of performers.

Creative development and start of concepts

I had been involved with the Company in a creative development project approximately twelve months prior. This involved three days of workshops in a drama studio with audio equipment set-up in the rehearsal space for rapid testing of ideas. The set-up was modest including just a laptop and four-channel speaker system. One idea arising out of this development project was that a singular sound should identify *K*'s state and entrapment in an absurd, unknowable set of circumstances. This sound was to "permeate the space of action and the conceptual field of the text."[78] The creative development took place at the Melbourne Theatre Company's rehearsal and workshop space, located in South Melbourne. During a particularly poignant moment in rehearsal, a circular saw started grinding and tearing on the far side of the building. The spatial perspective created by the distant saw permeating our space nonetheless created a tension ideal to the state of *K*'s mind under interrogation. I quickly proceeded to record the saw for later processing. The examples used in the final creative development, and an early sound event of the final production, appear in Sound example 23.

> *Sound example 23:* K *original saw and processed version*
>
> *Sound examples 23.1 (Bandsaw-original) and 23.2 (Bandsaw-pitch-shift) are the original circular saw starting up and the processed version. Sound example 23.2 was used in the final production at the point where the main protagonist K is placed inside a software algorithm. See Sound example 25 for full version. The second example (23.2) was produced by pitch-shifting the first in Hyperprism via an envelope that still maintains the impression of a machine engaged in a start-up operation.*

While the actual sound of the saw was not appropriate to revised versions of the script and first production, the concept of a singular iconic sound was maintained. The 'software sound' or 'algorithm' as we called it, was developed during the rehearsals to achieve a number of theatrical devices. Another significant aspect for me in the pre-project development of *K* was

78 From lecture notes held by the Author, 2003.

a conversation between David [Pledger] and I, in which we established a common collaborative field. David's theatrical practice is partly concerned with the ways bodies are distributed in space, where I view electroacoustic music as distributing energy in time. This shared concept about the importance of spatial organisation was an opening; a shared platform from which it was possible for me to work toward the sound design as an acoustic set, enveloping the space of dramatic action and incorporating the audience within a field of sound, while highlighting the physical connection between actors, idea and audience through a spatial acoustic environment.

The role of the sound design

The sound design for this production operates as a wave that takes us in and out of *K's* world, rapidly transforming the physiological setting of the narrative space. My approach was to find the precise sound that would most effectively convey this change of scene, or set the narrative plane. The reason for such economy is that sound is only one element, or layer of information that the audience must absorb alongside the other major stage design elements. For example, the set design for *K* includes twenty-four televisions and a large screen projection along with lighting (For the Melbourne staging of *K* see Image 23 on page 154).

At the time of the Vienna performances of *K* in May of 2003, David Pledger and I delivered a colloquium at SIAL, which included a discussion on the role of the sound design in the production. Extremely accurate timing with the performance was demanded of the sound operator and a fast method to deliver pre-recorded texts as part of the on-stage drama.[79] As a project in itself, the software environment developed for the performance proved to be a flexible way for producing polyphonic spatial sound designs that could evolve in the rehearsal period toward a final 'run-time' version used for the performances.

Elements of the sound design

The primary materials of the final *K* sound design were:

- approximately forty trademarks, or 'blip-verts'
- the algorithm sound and its crescendo over the show's second half amplified actors voices
- drum beats for the game-show host that were also 'played' via key mappings
- a chorus of chants, clapping, laughing and cheering
- pre-recorded video sequences of guest characters, appearing on TV screens
- miscellaneous sound effects, for example, the so-called 'voice of God', the system crash, and the opening, scanner sound developed for the Vienna performance.

79 For the performances in Seoul, the character of K spoke in Korean, while the main interrogating officer spoke in English. All the trademarks were re-recorded in Korean a few days before the dress rehearsals and used for the productions in Seoul.

The dominant elements of the *K* sound design are the trademarks and the algorithm sound. The latter is discussed in *K: the minimal sound of psychological dominance*, (see page 158). The largest quantity of material was the trademarks. In the first studio recording session, around thirty of the trademarks were recorded, each by two male and one female speakers, which I then edited and experimented with using various types of audio effects. For the Melbourne and Vienna performances, the female versions recorded by Tamara Saulwick were used. Tamara was able to imbue her delivery of the short texts with a metallic robot-like quality achieved through clipping or truncating individual consonants. I emphasised this effect by editing each trademark so it took on a machine-mediated quality. The sound was similar to a computerised phone menu or public address system, where the millisecond gaps between words or consonants are removed by the sample accurate programming of the system. No other processing was applied to the trademarks. For the Seoul performances, a local female actor recorded the trademarks in Korean, which I then edited prior to the final rehearsals after language verification by a Korean-English translator. English examples of the trademarks appear in Sound example 24.

Sound example 24: K *- two examples of original spoken text and text post-editing*

Early in his interrogation K *is permitted to call his lawyer but is placed on hold. Sound example 24.1 'You have reached…' was preceded by a dial tone and electronic signal removed here so the durations of the two examples may be compared. By editing the pauses of natural speech to suggest an electronic voice, the duration of Sound example 24.1 is still intelligible at almost 5 seconds shorter than the original version of Sound example 24.2. In Sound example 24.3 (Interactivity-edited) the editing of natural pauses and the first milliseconds of the words gives the text a 'clipped' sound often heard in automated announcement systems. Compare this to the original version in Sound example 24.4.*

In the fully corporate society of *K*, ideas words and emotional responses are made commodities. Pledger's text is well crafted such that the suspension of belief required of the audience is minimal. At one level, the trademarks are the aural equivalent of the "TM" (™) symbol appearing in ever-increasing frequency on logos and phrases of text in marketing. The text implies that is as if the English language, the ideas and emotions conveyed by that language, are being privately acquired and their use limited by licence. *K*'s entrapment in the system is substantially achieved by the system's occupation of his individuality through acquisition of his thoughts, which are 'captured' in the production–interrogation and converted to audio trademarks. Several of these elements can be observed in Video example 4.

Video example 4: K *performance excerpt*

This excerpt is from the Melbourne performance of K *in the Touring Hall of Melbourne Museum.*

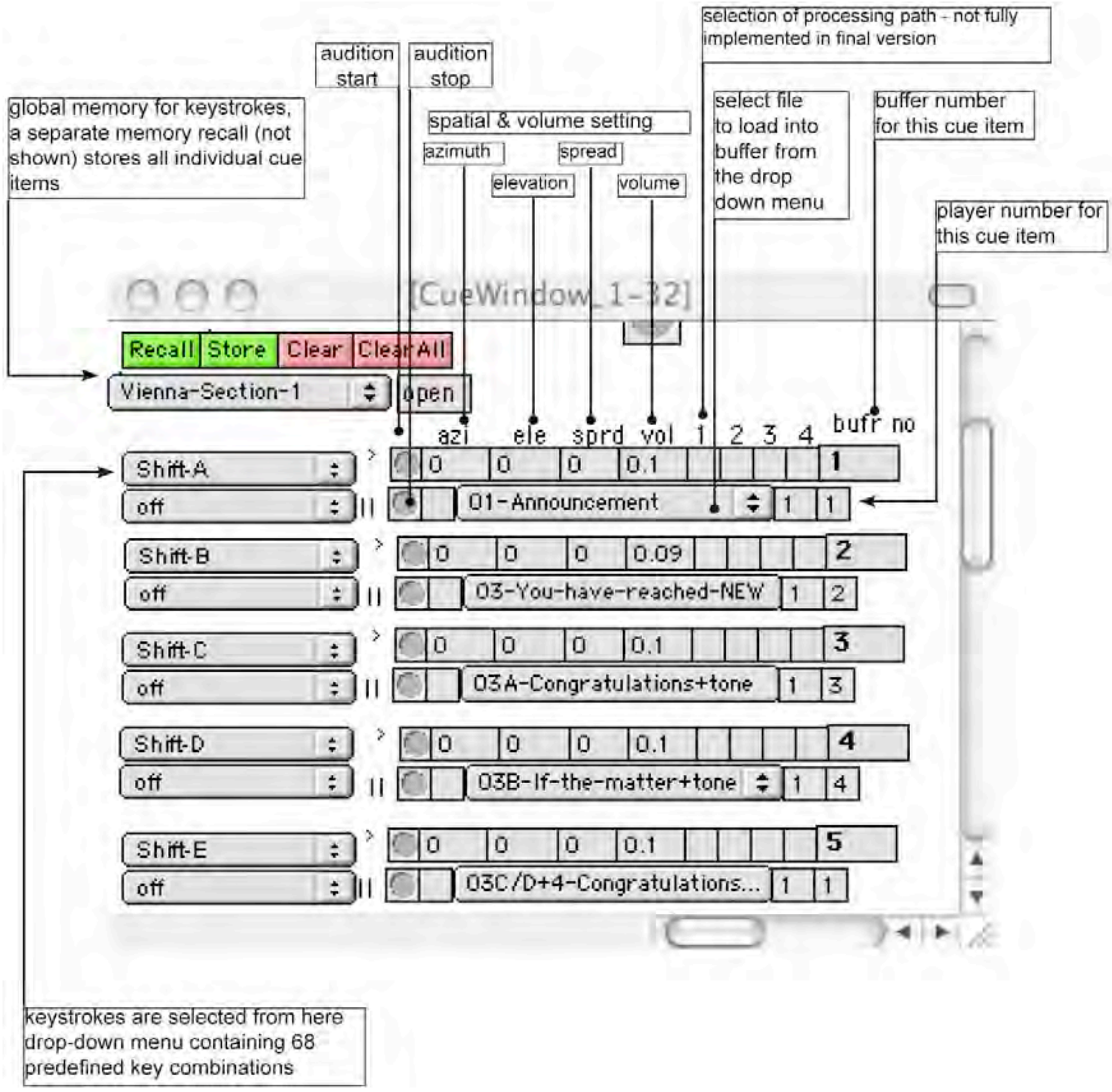


Figure 12: K *trademark player*

Each trademark is a cue with unique parameters for trigger keystroke, azimuth, elevation, spread and volume. The audition start-stop buttons allow for quick testing of a file. Some item parameters e.g., processing paths were not fully implemented in the final version. The keystrokes associated with a file to make it play are selected from a drop down menu on the left of the cue. The whole group of files and linked keystrokes can be stored and recalled as a 'bank'.

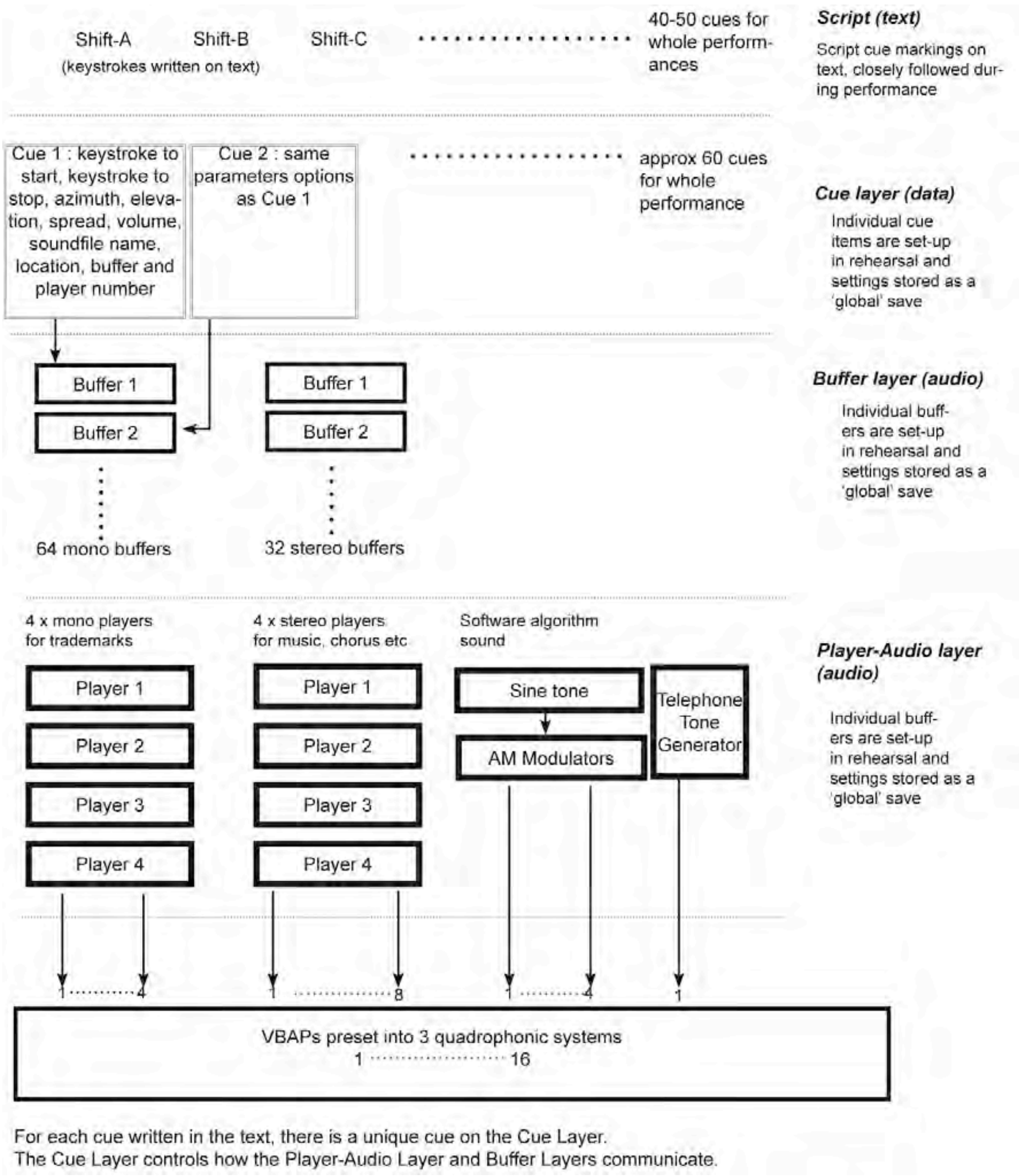


Figure 13: K *software schematic*

Overview of production schedule and tasks

One of the exciting aspects of theatre and performance is the immutability of deadlines. The show, quite literally, must go on. As a working environment, I find the imperative to think creatively and solve a myriad of problems within an over-arching artistic concept a sure way to test the strength of one's conceptual and technical skills.

The production for the sound design of *K* included:

- collaboration with *NYID's* director, actors and other designers
- design and integration of the audio amplification system into the physical set
- recording and post-production of material
- integration of all sound sources including radio microphones and pre-recorded video
- development of the software environment in Max/MSP

The final recording sessions for the project are summarised in the following table.

Session No.	Main material recorded	Date and time
1	trademarks	Monday 26 August, 2pm-4pm
2	chants	Thursday 3 October, 5:30pm-6pm (Horti Hall rehearsal space)
3	(no notes)	Monday 7 October, 3:30pm (finish time not noted)
4	chants	Monday 14 October, 4pm-5pm

Table 16: K *recording sessions' sound design*

The development of the script for *K* was an evolving process during the first production and because the recorded trademarks and script were so organically intertwined, changes in the script had to be rapidly accommodated into the sound design. This proved imperative, as in rehearsal, the director could assess as much production design as possible against other staging features such as lighting, large projection and blocking of actor's positions. Following each recording session, I would have to edit, and reprocess the new material often requiring incorporation of up to twenty new sound cues, some in multiple versions. On two occasions, an early evening recording session was followed by a 10 am rehearsal the next day. The software system I designed had to accommodate such quick turn around times during the intense production period of a large-scale work.

The *K* soundscape is not meant to be pleasant or attractive in any way. Indeed, the trademarks are disruptive of the flow in an excruciating manner, relentlessly disjointing the foreground narrative. The algorithm sound, although never amplified to a level that will cause physical harm, is distressing in its intensity of modulation, while the surround speaker configuration discussed later, brings the audience and K's interrogators into closer proximity where the hopelessness of his situation is palpable. Because the sound design can work at different levels of presence, that is, from background to conspicuous foreground, it is imperative that a sound designer be included early in a production. A sound design can work with the narrative text, the environment, the emotional or psychological state or transform the space of action from the purely physical to surreal space. As a sound design is both temporal and spatial intersecting other design elements, the sound designer has to gauge what might be called the 'weight', or position of the sound in relation to all other design elements.

Conclusion : expanding the field of practice

The five projects discussed here featured close collaboration with practitioners from theatre design and performance, media arts and architecture, and were realised in theatre, urban space, exhibition and virtual reality installations. In all contexts, my motivations toward the materials and their organisation in space and time are intended to heighten the spatial awareness for the listener. Over the course of the projects, two different approaches emerged. The first of pre-rendered studio-based work, and the second involving real-time software control that permits the designer to craft the work through data or interactive control. Where the two *Canopies* projects, and *Symbiosis* were characterised by pre-rendered sounds and through composed forms, *Ecstasis* and *K,* were based on more complex real-time processes in purpose-built software environments. A substantial amount of data must be developed and managed to deliver a complex sound field in real-time, even if the sound design includes a limited number of sounds. While this data field itself can be a shared territory for collaboration, it also demands an additional skill set on the part of the sound designer and those collaborators.

A spatial sound design requires another dimension of attention from the creator of the work. In the stereo formats for conventional cultural experiences such as film, television and most live theatre productions, the location of the listener is firmly in front of the work. Story-space stretches across the visual field, usually bounded by the loudspeakers. For a spatial sound work, the composer is required to attend to an additional narrative, which I suggest is a spatial one that will be constructed by the listener from the available source locations from which sound events emanate. The construction of this narrative, unravelling as another layer to the work, becomes a unique attribute of that work. The impact of the materials and their materiality can be strengthened, or weakened, by the method employed by the designer to articulate this narrative. If these projects were the subject of research in computer music, the reflective component would emphasise description and analysis of the technical realisation of the works. As this research was conducted in a school of architecture and design where making and reflection on making are paramount, I will now examine selected conditions affecting the origins and realisation of these projects.

3.0 Reflection on Making and Materials for Spatial Sound Design

Introduction

In describing some of the conditions and endeavours required to bring the projects of this thesis into being, I intend to illuminate the practice of spatial sound design for other designers primarily working in visual domains. The line of description I follow here is also aimed at research students or designer-composers in the early years of practice, wishing to view another's process as a means of positioning their own development, or to gain a different perspective on how a work is made relative to its scale. I also address 'making' in a way potentially useful for collaborators with a sound designer seeking to understand the possibilities and constraints around the practice of spatial sound design. Some of these ways of making are shared by other design disciplines. For example, at one level, the process of architecture can be described as one of assembly. Most of the elements are already made, such as bricks or door handles, and are then selected by the designer. The builders, or makers put them together. In several of the projects described below, the process of assembly from generated components can also be observed.

This chapter is divided into two main sections. The first considers intangible and logistic elements of making from their starting moments and the role of the brief, to temporal aspects of making the projects, through to issues on versions and archiving. The second section is grounded in the technological components used to deliver the projects. It focuses on aspects of production related to the projects.

3.1 Describing and analysing the logistics of making

To construct the descriptions in this section, I have drawn on diary notes translated into tables of work periods, photographs of places of making and presentation, schematics and images developed from workbooks and screen-shots to show how the projects unfolded. I view the description and analysis of these materials as exemplifying the difference between 'making' and 'production'. Making includes the conceptual issues local to, and surrounding issues influencing how the projects came into being, for example; starting intentions and compromises, the role of brief and management, specific spaces of work, qualities of time and its passing during making, or the role of technology and its application. Production is limited to the specific work undertaken in the sound studio that is done to produce, transform and otherwise bring into existence the sound materials of the projects.

Provenance of projects

The starting moments of the projects in this PhD are diverse. On reflection, I consider them to fit across three categories: conversation, invitation and opportunity. In placing the starting positions of the projects in one section, I am seeking to convey the ways the motivations for projects have changed as my practice has changed. The starting points, or positions are laid here as stepping-stones, dispensing with the need to then wade through the projects themselves. To use an electroacoacoustic analogy, the transients, or starting conditions are presented here isolated from the subsequent morphology of the project.

The origin of *SoundSites* can be traced back almost ten years prior to the Project proper, where a long-held intuition of mine found a place for realisation through a curatorial proposition from independent curator Samantha Comte. The Project was a return to purely creative, as opposed to curatorial projects with which I was pre-occupied over the previous four years.[80] The idea of an exhibition using only headphones and didactic panels involved a long gestation. During my undergraduate degree during the late 1980s, I started attending the 'blockbuster' exhibitions in major galleries in Canberra and Sydney. I noted that prior to entering the exhibition space, visitors have the opportunity of hiring a spoken commentary tour of the exhibition. This often consists of a 'celebrity' voice narrating information on each work. The visitor wears a headset connected to a playback device with randomly accessible track numbers. The traditional didactic panel and a track number for the narration accompany each artwork; users may then select track numbers for commentary on an individual artwork. I observed that with the provision of this sonic description, visitors would often quickly glance at the work and then stand staring fixedly into space listening to the narration, turning to the work only when prompted. If several people where listening to the same track at the same time, a strange choreography of heads and eyes simultaneously darting around important features of the work sometimes occurred. From these observations, I theorised that gallery visitors were prepared to stand and just listen and, despite the dominance of visual stimulus in art galleries, visitors' attention might be held by minimal visual material in concert with a rich aural experience.

Canopies was a self-generated project, that responded to a general call for proposals to *texture*, a public art funding program then operating from the Southgate Arts and Leisure Precinct. The successful application for *Canopies* led to a commission and the work being undertaken. *Canopies: concert version* was propelled by two forces. The first was my attachment to the sound palette created for the installation version. These sounds had been created during extended studio sessions between November 1999 and the completion and installation of the work in early 2000. As much of this material was improvised in the studio, I had formed a physical attachment to it. The second was a desire to explore ideas about composing for diffusion systems. Following my concert experiences in Paris, and artistic direction of two large electroacoustic music series in 1996 and 1998[81], there were many ideas I wished to explore about

80 Between 1996 and 1999, I did complete a work for double bass, electronics and tape, and a sound design for a public sound installation called *Flight Paths*, along with a work for channel UPIC-generated tape and percussion quartet.
81 These were *The Reflective Space* (1996) and the *Contemporary Music and Sound Series* for Next Wave Festival (1998).

producing a two-channel work for twenty or more loudspeakers. Having heard the *Canopies* installation version live on site for a three month period, I also had time co-exist with that material, which triggered yet more ideas about its further crafting into other sound worlds/environments. Finally, Curtis Roads invited me to make a work for the concert series at the Center for Research in Electronic Art Technology (CREATE) at the University of California, Santa Barbara so the motivating force of a concert deadline came into play.

Symbiosis started with a conversation between fellow postgraduates Jonathan Duckworth and Mark Guglielmetti, and followed soon after by collaborative workshops. During the initial discussion, we had posed a question as to what the artistic applications of industrial-military simulation technologies might be? Although a concept may have been documented in a brief, or grant application, the momentum to continue to start-up phase must be carried in order to overcome inertia. The start-up phase is the crucial time where ideas must seek the means of traction, where one must project (as in 'externalise') the project (the planned undertaking). The beginnings and key project decisions of *Symbiosis* had several implications for the subsequent *Ecstasis* project. In some ways, *Symbiosis* was a test project to *Ecstasis*, while *Ecstasis* can be viewed as the final section of *Symbiosis*. Where *Symbiosis* had a gradual nascence into the world, *Ecstasis* was brought forcedly into a difficult working environment.

Jonathan Duckworth initiated the collaborative partnership of Metraform. We met in a research methods class during 1999. Jonathan invited Mark Guglielmetti, also employed at the VR Centre, to be the third member of the group. Our aim was to investigate the production and delivery of an experimental artwork using the in-place technologies of the VR Centre. At this time, our work was funded through a combination of scholarships and other paid work. There was no additional support for programming or hardware, although this was later quantified and successfully sought for *Ecstasis*.

The sound design for *Symbiosis* started with a series of workshops between Jonathan and myself combining early visual renders of chambers with existing sound materials from *Canopies* and previous compositions of mine. These workshops involved projecting animations looping around simple camera paths with multi-channel sound mixes. Other preparation work we undertook at this time was an investigation into the audio capacity of the VR Centre technologies to develop and deliver a large spatial sound design. The results of this investigation led to the indicative soundscapes of *Symbiosis* and informed the software design brief for the Max/MSP programming of *Ecstasis.* The VR Centre operated on technologies developed for high-end industrial and military simulations. The next most likely use was architectural simulations of historical sites, projected buildings and urban spaces. The various interconnected production platforms, and the runtime software *Vega* were never intended for experimental art projects. In not requesting further resources, it was possible for us to conduct the investigations for *Symbiosis* in parallel with other commercial work being undertaken at the VR Centre. A case of 'stepping lightly' on the facility, also meant much of our work was undertaken after hours and on weekends, along with our bookings being moved aside in favour of commercial and other work that would take precedence. Both Jonathan and Mark have estimated the time to develop a production model suitable for creating real-time 3D models for *Symbiosis* took approximately twelve months of working in this way. This involved determining all steps from conception of a model, to its optimised delivery on the Vega platform. One issue with the adoption of industrial-military technology was access to existing technical knowledge. The manuals for this software were not useful and additional technical support was difficult to access, as compared to other large military or industrial simulation centres, the VR Centre was a small client.

The VR Centre had opened in 1999 at which time a Lake DSP System was to be the main audio spatialisation engine of the facility. The methodthis was to operate proved more theoretical in application than practical. Within the main runtime application that was used as the upper layer of software for the Centre, a platform entitled *AudioWorks* was intended to be the primary workspace and delivery platform for audio in large VR projects. At the time, a communications protocol operated between *AudioWorks* and the Lake system. In an upgrade between 2001 -2002, this link was broken. In the process of developing and learning the system, we discovered other issues such as the xyz coordinate system for audio in the room was incorrect: positive z appeared to be pointing down. Another difficulty involved the proximity effects of audio. The process of approaching an object with sound emitter attached quite rightly caused the audio to fade in, as if one was walking toward a sounding object in real-space. When moving away, one would expect the audio to gradually fade-out to silence. This would start to occur, but would dramatically cut out before reaching silence.

To determine the correct parameter controls for a simulation and to hopefully generate a better understanding of the audio platforms in the VR Centre, I designed and executed several objective tests. Other VR Centre staff members were able to achieve the movement of single sound objects around the space, and these while useful, proved more technical demonstrations than extensible techniques on which a complex spatial sound design could be developed and deployed on the platform. As the audio system would not operate in the usual collision detection model of most simulation environments and games engines, I had to conceive an alternative method on which the sound design would be developed.

There were two solutions to this set of constraints. For *Symbiosis*, a series of eight-channel linear mixes based on complex sound transformations, but limited spatialisation were developed as a way of completing the Project for its premiere at the Melbourne International Film Festival in 2001. The final format of producing multichannel mixes of up to 8 stereo channels (16 mono channels) at the VR Centre ensured that the spatial design could be conceived and delivered precisely. This pre-rendered solution guaranteed that the work would be completed in time, and also relied on a minimum of software assistance and communications with other parts of the VR system. The eight files originated as a script file when the eight minute camera path commenced the journey through the environment. I named these designs *indicative soundscapes*, as the materials of the works were those that would have been populated through the environment, and triggered using standard simulation techniques of proximity and panning effects caused by orientation. I wanted to avoid the sound track notion in these indicative soundscapes of strong casual identity. In part, this proved simple as in most chambers there were no events – something happening at a given time and place – that could have had implications for the sound design. For *Ecstasis*, the complex sound transformations, data and gesture control, and spatialisation were achieved through a purpose built Max/MSP patch. The sound processing modules employed are similar to those used in *Symbiosis*, but the potential for spatial mixing and interaction afforded by the change in software platform was more sophisticated than in *Symbiosis.*

The collaborative conversation for *K* began through a mutual friend and collaborator, Paul Jackson who organised a meeting with *NYID* Director David Pledger. The collaborative connection, or link was formed through our individual positions on the central organising principles of our own artforms. For David, it was the distribution of bodies in space. For my own part, it is sound-based composition as distribution of energy through time. The Project also became an opportunity to realise the idea of an acoustic set occupying the playing space, and audience attention in a circumambient fashion. The director intended the sound design to be a primary visceral element for the audience.

CitySounds was an opportunity made real through pursuing a commercial contact with the City of Melbourne Noise Unit. In 2001, the City of Melbourne released a strategic Health Plan that included analysis of, and intended strategy to deal with, key health issues in the City of Melbourne. I was surprised to note the extent to which noise was deemed a health problem in the CBD. In this plan, over 30% of all health complaints were noise related. Dr. Neil Maclachlan and I put a question on notice to a people's forum organised by the City in which Council sought feedback on the Report. We asked what the Council intended to do about one of the major noise complaints issues identified in the report, that is, noise. On further negotiations with Council officers, it became apparent that the primary informational resources for making decisions were measurements, advice from acousticians, or complaints about noise. Early development for the SIAL Sound Studios commenced soon after these preliminary negotiations. In the intervening period, I taught specialist sound courses for *Memory Games,* a design studio using the Torque Game Engine. Students were to construct a realistic laneway of Melbourne through which a visitor entered a world created from memory. The process of advising on the sound design for fifteen student projects refined my thinking and technical knowledge of the ways a game engine could be used for soundscape research. Once development on the Sound Studios had progressed to a point where we could undertake commercial projects, I approached the City of Melbourne to re-activate our earlier discussions on a community research project. The result was *CitySounds,* discussed extensively in Chapter 5.

Aspects and inter-relations of brief & management

As a composer working either on individual projects or collaborative arts commissions, I found that the creative development and production of a work commenced from a very general set of agreed attributes. Perhaps as part of the commissioning process, general details are determined and agreed upon between the parties involved. These might include duration of work, instrumentation, date and place of first performance, intention to record or broadcast the work, or commitment to number of performances.

General plans for *SoundSites* and *Canopies: chimerical acoustic environments* were developed as part of successful grant and commissioning applications. The audio components of *Ecstasis* were similarly detailed in an application to the Digital Media Fund and later formalised in a contract. *CitySounds* evolved from a brief, and progressed to a formal contract between RMIT and The City of Melbourne. While the level of detail required for these documents might at first appear an onerous administrative task preceding more creative ones, I prefer to take the perspective that an application, or contract can function as a project plan in two ways. The first is to provide a selection panel reader or client with a clear picture of what the project is intended to be. In the case of an application, it also provides convincing evidence that the applicant is capable of delivering the intended project. The second is to overcome the common time lag involved between making an application or submission, and the point were sound design begins. At the time of conception, the project descriptions will have a particular vitality or energy, unconstrained by the compromises that inevitably creep into processes that dissipate over time. The concentration of this catalytic moment into words can provide a sustaining creative energy throughout an extended project. Of the seven projects discussed in this thesis, only the concert versions of *Canopies* and *Symbiosis* were produced without funding from a commissioning body or commercial client. The remaining five were preceded by a document projecting their making. Both *Canopies* and *SoundSites* were made to a specific, if very simple, project description. At one level, while I accept the necessity of a brief, it was liberating to work unconstrained by a pre-determined plan for the *Canopies: concert version*. The return journey through the palette of the installation version was made on a simplified technological platform and with simplified logistic considerations, at least during the making stage. Another useful role of the contract is to ensure agreed outcomes. During one round of project negotiations to finalise a contract, our legal representative succinctly advanced another useful role of the brief - to set the conditions so the client would approve work on objective criteria not subjective assessment. In *CitySounds* and *Ecstasis*, the Project was to progress only through the artists and designers meeting previously agreed criteria assessed in milestone presentations.

Collaboration is a disorderly business. It can be difficult to determine how, or even if, progress is being made, or whether the endpoint of the project is nearing. In fact, the act of establishing the end point itself is almost a 'truce'. That is, an agreement that when the work is describable in a particular way, then it will be deemed completed. At a communicational level, the brief and contract are also useful for managing the complexities of an expanded practice that I view as a consequence of my development from individual artist to sound designer and researcher. The time-line plan and budget are useful to define the roles of other project workers, and to succinctly describe what is expected of others and when that work is to be delivered. The milestone structure of commissions from the Digital Media Fund (DMF) was a discussion point amongst the group of artists working on projects funded around 2003 - 04. Opinions were mixed. For most people, having to declare what would be achieved by a specified date and to explicit budget parameters presented a new professional obligation, although one familiar to brief-contract driven professions such as architecture. I personally found this a useful mechanism for facilitating collaboration. Although the technologies and visual-aural languages of *Ecstasis* were difficult to explain, I determined that completing the sound design was still contingent on the visual being 'locked-off' and not subject to further changes. In *Ecstasis* and *CitySounds*, the timelines and delivery of programming, audio and visual components had to be closely coordinated. In early stages of the software environment development, I attempted to make the sound software system too open ended, too generalised. My intention was that the system could be used later for other projects in the VR Centre. Indeed, the notion of re-purposing was a reasonable one. Since *Ecstasis*, many of the objects, or Max/MSP techniques I used in the Project were exchanged with *K*, and other projects in the SIAL Sound Studios, particularly in the sound diffusion system control project.

At the time of its production, *Ecstasis* was the largest budget project undertaken at the VR Centre. As such, it represented a showcase for the Centre. This constant peering into the process proved disruptive at times, mainly due to the Project's shifting nature and the difficulty of explaining the work through material that was essentially prototype sounds and images. At different times, the audio environment was not in an appropriate state for demonstrations. Contingency plans involved the selection of a track from a CD of material I had pre-prepared. On the other hand, the milestones meant that collaborators had to make a declared position, or decision known not just to the other members of the team, but also to an external body.

My role as Creative Director of *CitySounds* was to ensure all elements were developed closely and in parallel, including the survey design; soundscape recording and design, spatial planning and visual modelling, software control and online survey reporting system. A sound issue, or new questionnaire theme needed a physical location in the model, including structural or object design, background research question preparation, and a new holding frame for text. The initial project planning and brief were developed around three to four inner city blocks. I made digital asset and time management projections around the unit measurement of a city block. This was soon reduced to one and one half city blocks when we realised it would take too long for a participant moving at a walking pace through the model to complete the survey in the twenty minutes suggested by the social scientist researcher as the optimum duration. This reduction in scope was realised while preparing a more compact brief arising from the initial project meetings.

Delayed commencement and intervening projects

Despite the best-laid plans and concerted attempts to complete projects, inevitable delays have various effects. Not all these are deleterious. The time-lapsed period for *SoundSites, Canopies, Symbiosis, K* and early *Ecstsasis* work was 1999 to 2004, with several start-end overlaps in between projects. The conceptual development and commission application for *Canopies* was completed in October 1998, and the process was supposed to take between four to six weeks for a decision to be reached. Ultimately, it took much longer, so *Canopies* was put on hold as the application for *SoundSites* had been successful in the interim and this project commenced in the first half of 1999. The gestation period for *Canopies* was therefore, much longer than originally anticipated, and occurred while working on *SoundSites.*Although financially burdensome this was not an unwelcome position creatively. The large amount of time required to visit locations, listen and record for *SoundSites* was useful in focussing my own ear to the conditions of the acoustic environment in and around Melbourne. The *Canopies* start delay also affected an influence on my own aural imagination of creating *SoundSites* for headphones and spending considerable time with unsighted listeners. *SoundSites'* use of headphones positions it as a work of juxtaposing contexts: the headphones are intimate, yet the exhibition in a gallery is public. It is illustrates a personal engagement with another's experience of shared acoustic environments. Furthermore, the headphones are intended to block out the surrounding environment and focus the listening on the sounds of the work, where *Canopies* is an open work using a shared acoustic space.

As the *Ecstasis* project extended beyond its initial ambitious timeline of thirty-two weeks, I had to suspend development for eight weeks, while *K* went into production for the Melbourne Festival of the Arts in 2002. The main effect of these two projects overlapping lay in the technical development of their respective Max/MSP patches. The sound worlds of the two projects are significantly different with no opportunity for material to be shared as occurred with *Symbiosis* and *Canopies.* The hiatus in *Ecstasis,* gave me the opportunity to develop and expand the audio playback capacity of my Max/MSP projects, as *K* uses a bank of thirty-two sound file buffers, which was later incorporated into *Ecstasis.*

In early 2003, my position as Lecturer in the SIAL Sound Studios was confirmed. In this capacity, I was responsible for finalising the spend of a substantial grant for equipment. In 2003, the building of the SIAL Sound Studios Stage One was conducted in parallel with negotiations for the *CitySounds* project discussed below, along with completion of *Ecsatsis* at the VR Centre. Stage Two of the Studios' construction, which included *n-space,* the *Small Studio* and *The Pod* studio, commenced in the summer of 2003 - 04, and was completed in time for final mastering prior to launching the *CitySounds* project in August of 2004.

These larger scale time issues of practice are closely related to the discrete qualities of time discussed in the next section. The interventions of projects into each other may be a cause of time lapsed and may influence a new perspective on the time taken, or focussed time of discrete project work.

The temporal qualities of making

> *The remaining studio time would be divided into four periods so that all parts of the work, the first thirty minutes, the second thirty minutes, the* Listing, *and the places, would receive equal attention. Our minds were at ease. The work would be finished on August 15. (John Cage discussing the making of* Roaratorio: An Irish Circus on Finnegans Wake.[82] Italics are original).

When Cage completed *Roaratorio* in 1979, it was one of a few works to have been completed at Institut de Recherche et Coordination Acoustique/Musique (IRCAM) since it opened two years prior. Different practices have ideal targets for what might constitute a minimum output per day. I recall an anecdote from my music studies that Stravinsky allegedly aimed to produce a minimum of four bars per day. At this rate, a 250 bar orchestral work might take approximately three to four months to produce, with three to four completed works per

82 Excerpts from the liner notes, reproduced at <http://www.themodernword.com/joyce/music/cage_roaratorio.html>, para. 20, viewed June 26, 2007.

year. Another senior composer's advice was that it was necessary to work for only two hours per day, but this must be highly concentrated and undisturbed creative work, if one wanted a productive life as a composer.

There is no direct answer to the question: 'How long did it take to make this piece?' When asked, I usually respond with a qualifying interrogatory: 'Do you mean time lapsed or time taken?' The difference can be summarised thus: *time lapsed* is time that passes in hours/days/weeks/months between start to finish of project, while *time taken* is the total number of hours worked on project over the time lapsed.

Where time lapsed is easier to determine, aspects of time taken become obscured. Both measures illuminate the practice of making and communicate different aspects of making. Time lapsed has bearing on deadlines, delivery, event openings or a launch, that are mainly logistic matters. Time taken can be measured in the hours spent on the work and has financial implications for cost, materials and production resources. The two are tightly linked. Collaborators, partners, funding bodies and clients at different times demand a numerical and/or calendar measure for both types of time. Saying a task may take a week's work, can easily be misconstrued to mean that the work will be ready in one week, as opposed to thirty-five hours of production time over the next four weeks.

Time lapsed is important in describing the periods between project conception, project start (often marked by the commencement of successful funding application or receipt of the first cheque) and delivery of project. It also captures the time of creative reflection, when the conscious and subconscious mind is processing the ideas behind the piece. To that end, I prefer to start projects early to allow this fermentation process to take place and to work consistently through the process of tending to the ideas. This approach acknowledges the difference between making and production. Making is not just the rendering of materials but includes various tangible and intangible tasks. Time taken captures only the physical time in studios and collaborative meetings. Except in highly non-speculative projects, it is not a useful measure for the project. Embedded in these two types of time is the notion of the qualities of time, or the different types of tasks and activities that one can achieve at different times, which are in contra-distinction to a management sense of time or task time.

While one's mental and creative abilities are subject to daily fluctuations, the necessity of completing a work is such that awareness of one's own creative abilities, stamina and milestones to be achieved to progressively move a project to completion is critical knowledge for an artist/designer. For young artists particularly, this knowing is essential. In my supervision of Post Graduates, working through production plans in fine details, then taking a watching brief over progress has been based on the project information presented in this chapter.

For established practitioners, the assessment of a new scale of work – usually much larger – is a fraught and difficult decision, implying that some prior conceptualising is required to establish contingency plans and ensure the project is adequately resourced. While one's mental and creative abilities are never consistently the same, the demands of professional practice are such that some knowing of your own abilities, and what can be achieved over different time scales – one hour, a day, a week, a month – is critical. This is especially significant for auditory disciplines. Due to the effects of aural fatigue, it is not possible to spend many consecutive hours in a studio. The human auditory system loses sensitivity due to tiredness, compounded by the effects of coffee and other stimulants. Still, the project must progress, which is why I consider the qualities of time as a way of discussing other, perhaps more subtle tasks involved in making.

Knowing how long, or being able to accurately determine the time lapse and time needed for work, has profound bearing on budgets, quotes, project tracking, resource allocation, critical paths/dependent processes such as image production. Within project timelines are smaller embedded ones, along with interim and final deadlines – a rehearsal, a meeting, an interim presentation, a workshop, a focus testing or milestone, culminating at an opening exhibition launch, concert or broadcast. Assessing conceptual development and the time required is a little more difficult. Thinking and low-level mental processing occurs at different clock rates. My preference for early start times on projects also applies to beginning conceptual discussions or planning as early as possible, to allow maximum time for the ideas to sit in my unconscious processing. It is similar to a library, where I can take down a book project and mull over it. Finally, it is like a landscape for exploration in my imagination.

In the final sections of this thesis I discuss the SIAL Sound Studios housing a community of practice and a model for an emerging spatial discipline. In my role to establish the Studios, I had to envision the qualities of time and types of activity the studio facility would be required to support. Some of the qualities of time, as defined by the type of tasks that fit different work units or work sessions are summarised in Table 17.

Quality of time	Types of activity
Generative time	Recording, editing and processing of source material.
Production	The putting together of sound files in digital audio software.
Auditory imagining	Revisiting material only in one's imagination, that is, not through direct audition, and usually away from the studio environment. This is reflective time, where the ideal would be to limit the intrusions of other tasks and activities into one's mental space.
Listening time	Allowing temporal distance between the creation and subsequent listening of material, or sections on other loudspeakers than the usual studio workspace and possibly with other listeners.
Project material management	Includes data backups, shifting files between media sometimes for storage space management, workspace maintenance, managing naming conventions and descriptions, upgrading software and/or hardware, adding new VST's, tools, system or versions.[83]
Reporting and documentation	Critical in Post Graduate and research situations and commission or contract-based projects. Text written for thoughts during project along with schematics, photos, diary notes for studio bookings, screen snapshots. Includes lectures made on projects soon after their completion as primary source material, papers and notes from workbooks.

Table 17: Temporal qualities of making

Comparative evidence: actual project timelines

The chart shown in Figure 14 contains the production periods and dates of presentations (exhibitions, performances or launches) for each of the seven projects. The overlaps of projects and competing priorities can be observed, particularly in the period 2001 - 2004.

Figure 14: Global project timeline – A3 foldout

This figure shows all project starts and durations of the PhD study, along with performance and exhibition dates.

83 The *Ecstasis* project spanned the major Apple computer system update from OS 9 to OS X. The Project was ported between the two operating systems in 2003.

From this overall time line and assorted other diary and work notes that were maintained, I have calculated the time lapsed and time taken for each of the projects.

Project	Time lapsed	Time taken (estimate)
SoundSites	8 months	108 hours
Canopies - installation	3 months	70 hours
Symbiosis	6 months	265+ hours
Canopies - concert	2 months	54 hours
Ecstasis	2 years	1044 hours
K	6 weeks	80 hours
CitySounds	6 weeks (production only)	–

Table 18: Time lapsed and time taken

Comparison of time lapsed and time taken for each project. As projects overlapped and were remounted, time lapsed is calculated between a date when the project was the main focus of my work, to the first performance, exhibition or launch. Time taken has been calculated from diary notes. In the case of large collaborative work such as CitySounds, *the time taken is not included, as this would have to include cumulative work of whole team.*

Versions, histories and active archiving

> Nothing is more misleading than the illusion created by hindsight in which all the traces of a life, such as the works of an artist or the events at a biography, appear as the realization of an essence that seems to pre-exist them (*The Logic of Practice*, Pierre Bourdieu, p. 55).

In hindsight, I would have approached the *SoundSites* project differently. Whereas with *Ecstasis* and *Symbiosis,* it seemed I was working to an endpoint, a place where the work would announce its own completion, *SoundSites* was an exercise in prospecting. I believed, as an artist must, that there was a work in the idea of translating the experience of visually handicapped people into sound. In undertaking the Project now, I would have maintained more accurate diary notes in an attempt to capture the process leading to the point when individual acoustic moments crystallised, and to trace the Project's evolution to its culminating form. The minimum intervention by which this could be achieved is, of course, the problem, and one that is central to researching through design. By 'minimum intervention', I propose a mode of capturing thoughts, observations and decisions generated through the process of making as it evolves. Ideally, this would involve a method of capturing observations in a way that does not require one to stop working for too much time and can be undertaken in, or away from the studio using portable technologies or materials. For example, this might employ a combination of dated notes in workbook, spoken thoughts into a portable dictaphone, screen captures or interim versions of the project. Sound design does not have a readily available form of documentation similar to other design practices where a physical object might be produced through model making and photographed at regular intervals, or sketch plans compared as they unfold.

Electroacoustic practice has no comparable representation to the score of music, or the sketch and plan of architecture. However, the purely digital platform of electroacoustic production projects, particularly where there is a single software platform in use, allows a trace of versions to be assembled parallel to the process of making. In *Canopies: concert version*, *Ecstasis*, *K*, and *Symbiosis,* I followed a working technique of regularly copying the current work file, naming it as a version, and continuing on with work. The versions were made at moments of actual, or potentially significant project stages, which might be the addition of a new software audio module or improvement in a Max patch (*Ecstasis* or *K*), a major structural change in a linear composition (*Canopies* or *Symbiosis)*, or a number of new sounds introduced into the work. Sometimes the process of version-making was purely for risk management: a copy of a previous day's work would be saved to a different folder or media, usually not attached to the working computer. The versions are easily archived using the "Save As…" function.

Project	**No. of versions**
Canopies	15
Symbiosis:	
Nebsphere	12
Jesus *Modelkit*	11
Construct	5
Still Life	12
Backface	11
Landscape	2
K	17
Ecstasis	29

Table 19: Number of versions per project

Of all the projects, *Ecstasis* has the most extensive documentation and file versions, in part because it took the longest time to complete. I will discuss the unfolding of this project as it is summarised in Figure 15.

Figure 15: Ecstasis *history of versions – A3 foldout*

The main work periods and associated versions of the software environment are shown across the top of this figure. The images show a screen snapshot at the start and end of each period. Below the images are short descriptions of the main developments for a work period, divided into the key sections of the environment: audio, audio processing and data. The section called other is mainly for screen layout issues, CPU testing, memory management and storage development.

The intention behind this figure is to show a condensed version of the project stages and the somewhat disorderly nature of that progress. When using the *Ecstasis* project as Post Graduate teaching material, students often inquire as to the time it took it complete. The details of Figure 15 shows the duration of the Project's unfolding by meandering and spiralling around a central idea, taking on new modules and finding the boundaries needed to define and complete a working spatial sound environment. The type of work undertaken in versions 1 - 6 of Figure 15 is exploratory in terms of individual software modules and the organisation for the whole environment. The next versions (7 - 9) integrate the various types of modules for audio and data processing, while versions 12 - 19 involved refinements and use of memory data management. From version 20 - 29, further refinements occurred parallel to the use of the environment for completing the sound design. By making and keeping versions of the Max/MSP patches, I was able to construct this diagram and unravel the development of the project.

Another reason for using the version method is that over the course of a project, an archive is actively produced. If a major retracing of work is required, then the version archive becomes a way to return to a previous juncture. During the early years of this doctorate, audio files were large compared to the readily available and affordable portable media. In projects with large numbers of audio files, I would place copies of the files on my home studio computer and copies in studios at the University. While this meant I had safety copies of files on two computers, any changes to a file, or file structure on one computer, had to be mirrored on the other computer. Once the file structures of the two computers were synchronous, it was only necessary to move the upper 'calling' files between workspaces. These would be the Max patches or Pro Tools files which for both applications had files less than 500k, and these could be transported on ZIP disk, or later, memory stick.[84] Therefore, at any time, there are synchronous, or close copies on two or three different media: home computer, studio computers and the transfer media. I make additional occasional backups to CD as data and audio, and in some instances, the University computers were also backed-up via system administration.

In this section, I have provided analysis of making related to the projects, as a means of reflecting on the issues of creative production of spatial sound works. While the discussion here has been limited to my own work, it has generally informed the expanded field of my practice

84 In 1999-2000, a harddisk weighed around 1.8kg. Carrying such hardware daily on public transport was not an appealing proposition.

– the establishment and management of the SIAL Sound Studios – and specifically the supervision of other research in the Studios, particularly Post Graduate research. While Post Graduates may be technically proficient, they often lack a deeper understanding of how this technical proficiency is a part, not the whole, of a larger creative practice. In identifying issues that influenced the making of the projects, my intention has been to look beyond the material form of the works into the processes that shaped their making, but were not necessarily part of the conceptual framework informing the work. As all the projects relied on electroacoustic technologies for their production and delivery, the next section will deal specifically with these technologies and associated techniques.

3.2 Spatial sound technologies of the projects

I am particularly interested in how loudspeakers should be arranged, and what speculative arrangements are likely to provide other aural experiences. Spatial sound requires particular configurations of loudspeakers and other technologies in order to create virtual or phantom sources. Locating a speaker in physical space might at first appear to be a trivial exercise. Several technical aspects must work in concert if the desired outcome of delivering sophisticated spatial sound design is to be achieved. Commercial formats are a compromise solution. Stereo is the minimum with attractive features such as small data set (two streams of digital audio), while 5.1 is also a minimal arrangement, originally developed for film but again conforming to a minimum set of elements to deliver a solution.

The term *virtual source* describes the sensation that sound is emanating from vacant space between two loudspeakers, but not directly from any one loudspeaker. When this is successfully achieved, the sound field appears to hover above the physical confines of the hardware. However, the work requires grounding in some physically concrete way for it to be heard. It is ironic that an ephemeral artform such as electroacoustic music or sound design requires arrays of cumbersome boxes for its presentation.

While the physical location of loudspeakers in the VR Centre was fixed, the manner in which audio could be sent to these locations was variable. In the background to *Ecstasis*, I discussed the limitations and pressures in the VR Centre for spatial audio production (see *Ecstasis* section *Background and beginning to the project*). The end solution for *Symbiosis* was to use loudspeakers in paired groups, or interlocked stereo fields. There are some instances where a quadraphonic set-up is simulated, for example, in the swirling, vortex-like gestures in *Landscape* of *Symbiosis*. The communicative effect of stereo pairs criss-crossing the audience is still a potent one. It is really an octophonic field in four segments, or sections as shown in Figure 16. The loudspeakers in *Symbiosis* were paired as per the following table for each of the six chambers.

		No of input channels per chamber					
	Paired output channels	*Nebsphere*	*Modelkit*	*Construct*	*Still Life*	*Backface*	*Landscape*
No. of input chs per output pair	1&2	4	4	4	4	4	6
	3&4	2	0	4	2	2	0
	5&6	6	4	4	4	6	4
	7&8	4	6	4	6	4	6

Table 20: Symbiosis speaker pairings

In Symbiosis *channels were paired in interlocking configurations. The number of input channels assigned to each pair of output channels (1-8) in the final mixes of* Symbiosis. *The diagram shows how the input channels for each* Symbiosis *section changed and is one indication of the density of layers per speaker location.*

By referring to the assignment information in Table 20, a number of comparisons can be made about the placement of material across the six chambers. Where each channel has the same number of input channels (for example, *Construct),* my intention was to have a consistent sound field around the listener. Where a paired group is absent from the chamber (for example, *Landscape* and *Modelkit),* I had intended to have a greater separation between channels and audible layers of the work. The ominous lower frequency sounds that appear in some chambers often used the floor speaker pair '5 & 6', while the higher gritty textures are assigned to the loudspeakers above the audience – '1 & 2' – and those to the rear – '7 & 8'. Both *Backface* and *Nebsphere* use a low 'ground' sound, which is predominately assigned to the lower loudspeakers under the screen – '5 & 6'.

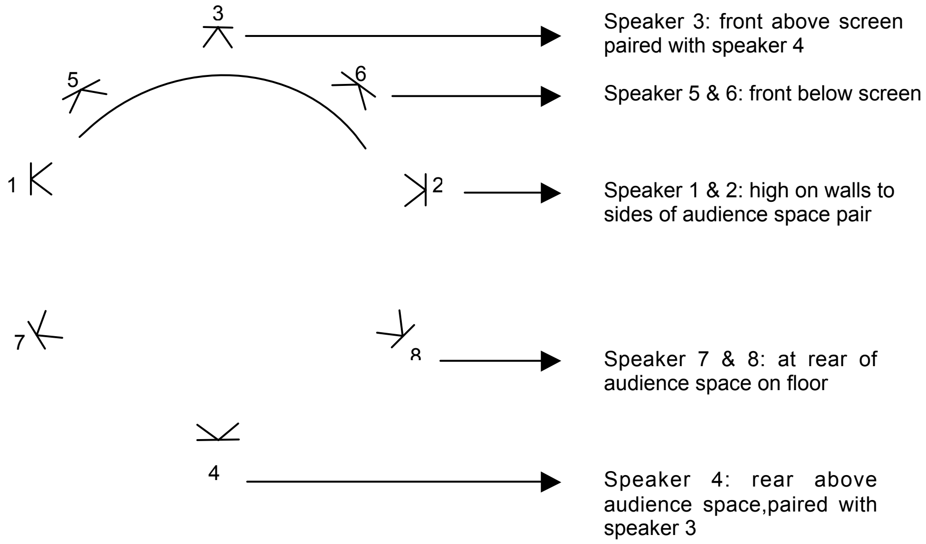
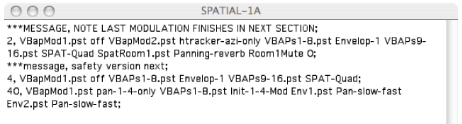


Figure 16: Symbiosis *loudspeaker channel numbers and locations*

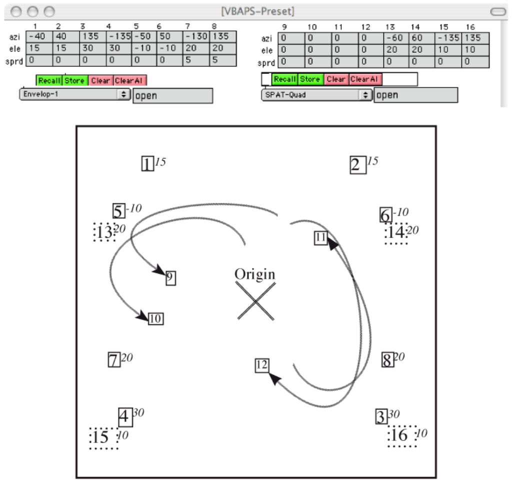
The numbers in this figure indicating speaker-channel numbers also appear in the Pro Tools screen capture images used in descriptions of the Symbiosis *chambers.*

Careful listening in *Symbiosis* can detect that sounds appear only on paired loudspeakers. During production, the pairings had to be strictly maintained or any spatial effects would be disrupted. It sometimes appears that motion is between more loudspeakers because more than one pair is used on occasion by embedding four channel sub-mixes inside the overall eight channels. In the available production facilities of the VR Centre at the time, limitations meant that relatively simply spatial motions such as a circular panning of a single source were not possible, nor were simultaneous strategies and layering of different spatial configurations. As *Ecstasis* developed, I realised that a significant difference lay between demonstrating, or achieving single sound positioning, polyphonic sound file playback and complex spatialisation techniques. To move beyond the mere technical demonstration of sound spatialisation into a spatial thinking with sound motivated the integration of several key modules for the *Ecstasis* environment. By using multiple matrix mixing objects, a single sound could be bussed across many different output channels, or many sounds bussed to the one output channel. Furthermore, the same sound and its processed versions can be mixed, or separated spatially as shown in Figure 11. In the final versions of the environment, sounds could be positioned on sixteen unique spatial locations around the listener using the *VBAP* object. As each *VBAP* location was controllable via various data generators, a combination of static and dynamic spatial strategies is simultaneously available. Each *VBAP* channel had a unique volume control, allowing static and dynamic balance of the overall spatial mix. Diagrams and associated data for two spatial sound scenarios are shown in Figure 17.



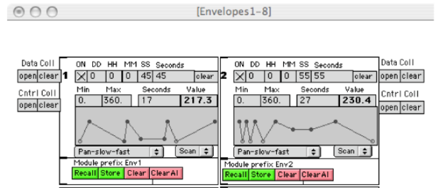
From the composition layer, a window showing control commands to initialise, start and stop presets in the VBAP windows and envelop window shown on this page. Scenario 1 starts at line "2". Scenario 2 starts at line "40". These values are seconds to achieve the two scenarios below. The head-trackers have been mapped to VBAPs 9-12 elsewhere in the patch.

Spatial scenario 1

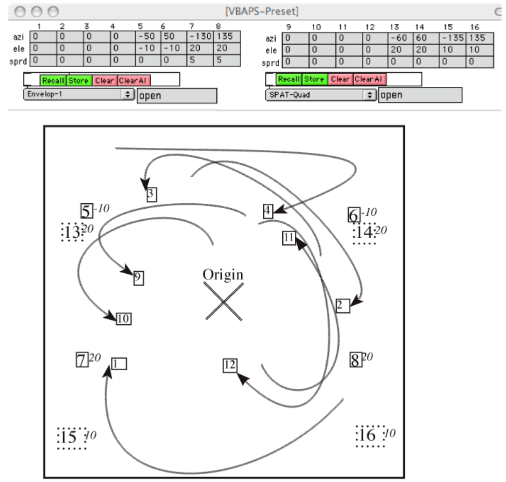


In this scenario there are 12 static and 4 dynamic VBAPs. VBAPs 9-12 are dynamically controlled by the azimuth and pitch data streams of head-trackers 1-4, mapped to the azimuth and elevation of the VBAPs. VBAPs 1-8 and 13-16 are static in the locations shown. The small italicised number to the right of a VBAP number indicates the elevation of that location in degrees. The Spat reverberated signal is on VBAPs 13-16. The origin is 1.75m up from 0,0 in the centre of the room.

Spatial scenario 2



Envelope settings for VBAPs. Env1 is scanning (a forward then reverse loop) over 45 seconds. Data values are 0 to 360 degrees. Env2 has a longer duration of 55 seconds, and different Envelope pattern.



In this scenario 40 seconds later, there are 8 static and 8 dynamic VBAPs. VBAPs 1-4 and 9-12 are dynamically controlled by data from Env1 and Env2, while VBAPs 9-12 remain controlled by azimuth and pitch data streams of head-trackers 1-4 still mapped to azimuth and elevation of those VBAPs. The 8 static VBAPs are 5-9 and 13-16. Note that the trajectory shown are indicitative of motion only, not the actual paths followed by inidividual VBAP objects.

Figure 17: Ecstasis *schematic of mixing locations for VBAPs*

The data required for two different spatial scenarios from early in the composition layer. Scenario 1 starts at 2 seconds, and scenario 2 at 40 seconds.

Canopies installation is also based around a set of interlocking stereo fields, similar in concept to *Symbiosis* but on a much larger scale. The Krypton system used in the soundscape system on the site allows loudspeakers throughout the installation to be grouped into zones. In the case of *Canopies*, there were four zones forming a corridor along the precinct and a central vortex. The Southgate System is asymmetrical around the cental vortex area as there are more loudspeakers at the Swanston St end of the precinct (see *Figure 3: Canopies site plan,* page 75). As with *Symbiosis*, the speaker configuration for *Canopies* was fixed but with a more flexible sound distribution system than the VR Centre. The use of stereo files was easier given that the material was developed on a small PC using processing software designed for processing mono or stereo files only. *Canopies* concert is what might be described as a *classic diffusion system* work, which can be mapped onto any arrangement of two or more loudspeakers. For the Melbourne premiere at the Victorian College of the Arts, the piece was played on the first, albeit small version, of the SIAL Sound Studios diffusion system. The second performance in Melbourne took place in the much larger space of BMW Edge, Federation Square.

In collaborative discussions with the director of *K*, David Pledger, I introduced the notion of an acoustic set. I saw this as a way of embedding the role of the sound design into the space of dramatic action, and also to conceptualise the sound as part of the physical presence alongside other design elements.

The final speaker configuration for *K* was influenced by the acoustic conditions for the first performance in the Touring Hall of Melbourne Museum and the spatial design of the performance area with the audience distributed equally in three locations. The Touring Hall has a parquetry floor and concrete ceiling. The space evokes a large box-like geometry with anaudience seating capacity of six hundred. The first issue to negotiate in the space was speech intelligibility. Actors were to use radio microphones in a text that ranged from intense and detailed interrogation of a prisoner, to a chaotic parody of a television chat show. Woven through these extremes were electronic sounds, sound effects, crowd sounds, public address announcements and music. The potential for this plethora of materials to dissolve into an acoustic morass was high.

The speaker configuration consisted of four loudspeakers surrounding each of the three audience zones, with a total of twelve loudspeakers. In each of the three zones, two loudspeakers were flown alongside televisions on an overhead gantry, and the remaining two loudspeakers per zone were placed behind the audience. Using *VBAP* to position up to three layers of sound at any time meant that separation could be achieved between the layers, avoiding audience fatigue from having to resolve masses of material in a single location, and to assist speech intelligibility. With the four-speaker arrangement around the seating areas and spatial panning techniques, the audience received a direct sound in an otherwise highly reverberant space. Although seated in a large space, it was possible to hear the actors' speech very clearly, without using high volume levels from the speaker system. Sound could be delivered equally to the audience listening locations.

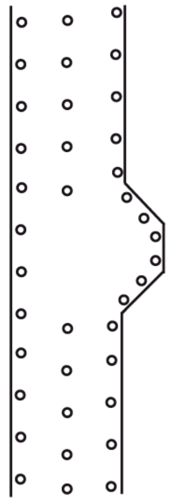
The *SoundSites* and *CitySounds* projects were presented on headphones while all other projects are loudspeaker-based. *CitySounds* can be listened to on PC loudspeakers. In *SoundSites*, the use of headphones relates to an earlier idea on sound and art galleries but also to allow mobility of the listeners in the exhibition space. The immediacy of headphone listening also supports the translation of auditory experience between sighted and unsighted listeners, which is a major component of the *SoundSites* project. For *CitySounds*, I initially investigated delivering the Project over four loudspeakers as a way of further maintaining contextual cues to the acoustic environment of Melbourne, however this would have greatly limited the number of users who could access the full version of the project in their homes. The use of headphones to shut off the immediate environment to describe another is somewhat ironic. R. Murray Schafer has described the significance afforded by headphone listening thus:

> … when sound is conducted directly through the skull of the headphone listener, he is no longer regarding events on the acoustic horizon; no longer is he surrounded by a sphere of moving elements. He *is* the sphere. He is the universe (Schafer 1994, p. 119. Italics are original).

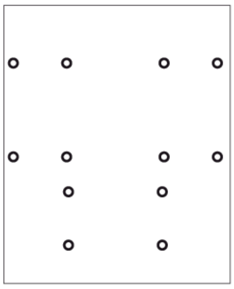
SoundSites was recorded in both ambisonic and stereo formats. The ambisonic recordings were immediately decoded to a generalised HRTF[85] using a Lake DSP system. Due to hard-disk capacity in the studio at the time of the recording, and without an easily accessible CD burner, only a small number of the original four-channel ambisonic recordings were maintained. Editing and mastering was then carried out on the stored two-channel version, and mastered using a pair of headphones that were the same as those to be used in the exhibition.

The final figure for this section, Figure 18 shows plan view diagrams of each of the projects. While the individual speaker diagrams themselves are not to scale, and in the case of the two *Canopies* projects, accurate in relation to the number of loudspeakers, it is useful to compare how each project changed in scale and dimension. The individual speaker diagrams are arranged from the largest number of speakers spread over the largest surface area to the smallest. Except for *Canopies: chimerical acoustic environments* and *Ecstasis*, the audience is static in the middle of the speaker configurations. The audience has the most freedom to move in the *Canopies* installation and some movement in the *Ecstasis* gallery version, although once fitted with tracking devices, the audience tended to stay in the middle of the sound field.

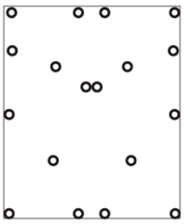
85 HRTF or Head-Related Transfer Function is an audio processing technique used to simulate the effects the human head and pinna have on sound perception.



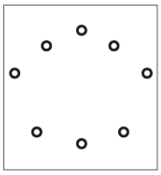
Canopies: chimerical acoustic environments: for 160 loudspeakers. The configuration shown is indicative of speaker group locations of the Southgate Soundscape system.



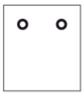
K: for three quadrophonic systems.



Canopies: concert version: for sound diffusion system. The configuration shown is indicative of the type of diffusion layout for a concert setting.



Symbiosis and *Ecstasis* : for 8 channel system.



CitySounds: for stereo speakers next to computer, or for headphones

SoundSites: for headphones.

Figure 18: Speaker configurations all projects

Each diagram is an indicative speaker configuration in plan view for the projects, although not showing precise dimensions or in the case of the two Canopies *projects, number of speakers.*

Making and presentation locations

Over the course of this PhD, the available production spaces at the University for spatial sound design improved considerably. This improvement can be evaluated through better equipment for audio recording and reproduction in studios and live scenarios, and improved sound isolation and low reverberation times for the rooms or studios in which teaching, research and production take place. Of particular note, is the progressive improvement from the studio used for *SoundSites* and *Canopies* (see Image 21) to *The Pod* Studio in the completed SIAL Sound Studios. While the first space was adapted from a room originally intended as a television production space, *The Pod* is a dedicated spatial sound research environment with a noise floor of less than 30db. The first space had poor quality resulting in added fatigue over long work periods, and noisy air-conditioning. The eight JBL Control-1 loudspeakers were useful for mid to high frequency audio production, but it was not possible to monitor lower frequency sounds in this room. While The Pod offers near pristine acoustic conditions for spatial audio, other spaces had conditions and configurations that had significant impacts on production. For example, the production space for *Symbiosis* and *Ecstasis* was a two-channel studio while the VR Centre presentation space was located on a different floor of the same building and equipped with an eight-channel system (see Image 24). The Pod was the only production space with suitable acoustic conditions for high-end audio production. The least favourable was the VR Centre presentation space as three large Barco projectors are mounted in the ceiling immediately over the heads of the listeners. To convince visual practitioners of the sub-standard level of this room for listening, I would ask them to imagine the effect of placing a skylight, or other bright light source mounted in the same ceiling, casting a beam over the screen. It would of course 'wash-out' or effectively destroy clarity of the projected image. Elsewhere, I overcame poor acoustic conditions with temporary solutions. The hutch used to record source material in *Canopies* (see Image 2, page 76) was an attempt to reduce air-conditioning noise in the studio used for the Project. In *K* and *Ecstasis*, I used a commercial studio. Capturing sound sources with little or no background noise is preferable if the sounds are to be processed at a later time. Audio artefacts that might be relatively low in level and unobtrusive, can add much extraneous noise after the fact. If processes such as convolution, or reverberation are to be applied to sounds, then it is preferable to have little, or no room qualities, or other sounds in the file.

The overall timeline for the PhD shows that from early 2000 to 2004, I was heavily involved in the establishment of the SIAL Sound Studios. Partner meetings, applications, planning, design and construction meetings, product research were all juggled around projects. I note in diary entries that it was a regular occurrence for a day of production to be gradually consumed either from the start or end of the day with obviously time-critical meetings or tasks for the Studios' development. Being able to quickly move in and out of production spaces and modes was essential to delivery of the projects, while also progressing development of the new Studios. This meant a project had to be quickly saved and remounted elsewhere when a suitable window of time became available, which for our purposes would ideally be a two hour minimum unless the task is a functional one, such as editing sound files. My own preference is to work early in the morning to take the opportunity of a sleep-refreshed mind, and prior to the administrative demands of the day taking precedence. In some cases, evening work is feasible, especially where tasks are time-consuming, yet not requiring the same level of concentration for example, editing the 'trademarks' of *K* as compared to processing sounds for *Symbiosis*.

Image 21: Studio on Level 7, Building 8, RMIT University

This studio was the production space for SoundSites, Canopies *and early stages of* Symbiosis. *The ambisonic recording box is in the foreground. This room is located at the rear of a building on the main University campus, on the 7th floor of a 12-storey building. Despite this physical isolation and the appearance of heavy drapes, the air-conditioning in this room is too loud for detailed listening.*

Image 22: K sound design desk

Detail of sound design control area for the first production of K *in Melbourne. Two sound operators were used for the performance. Each operator had a keyboard connected to one laptop as sound cues were shared between both operators. The operator to the left also controlled the mixer. The* K *Max/MSP patch is visible on the screen of the laptop.*

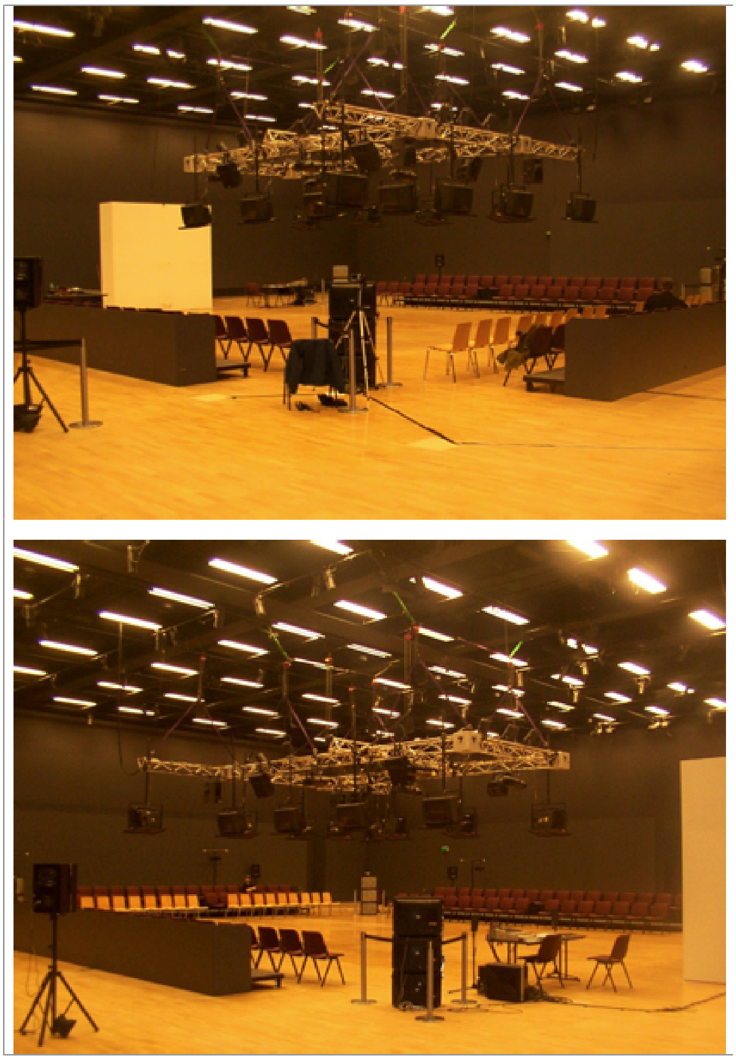


Image 23: K *Melbourne stage*

This image shows the set for K in *the Touring Hall, Melbourne Museum. Audience seating is around three sides of the playing area. The gantry above the playing area holds television screens, a projector and loudspeakers. The sound design control area shown in Image 22 can be seen in the foreground of the above image. Production designers for* K *were David Pledger and Paul Jackson. Image reproduced with permission from NYID*

Image 24: Symbiosis *and* Ecstasis *initial presentation space*

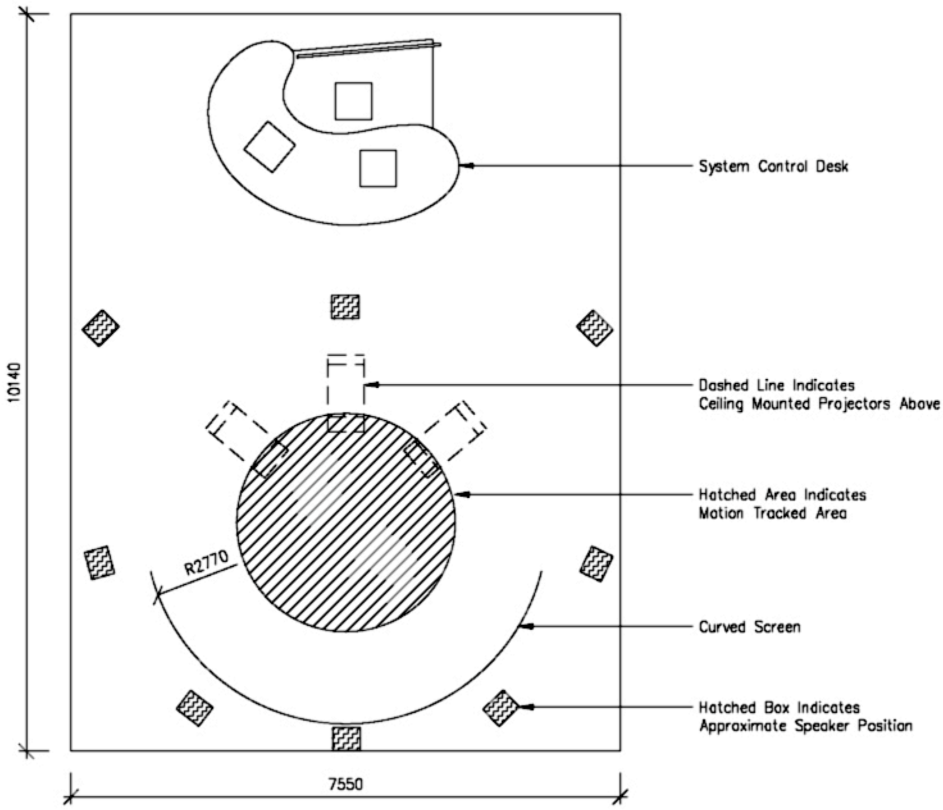


Figure 19: Floor plan of Virtual Reality Centre (VRC) at RMIT.

Diagram reproduced with permission from Metraform.

Image 25: Ecstasis *exhibition space 1*

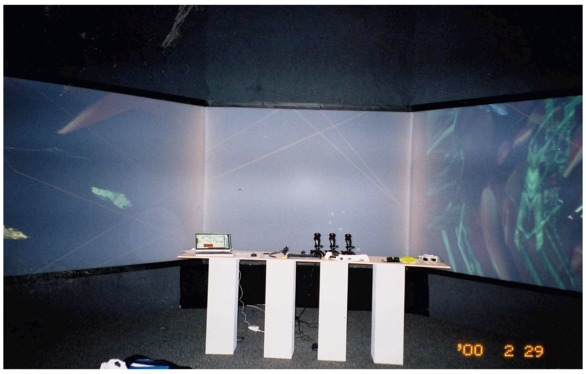


Image 26: Ecstasis *exhibition space 2*

Image taken during final stages of installation and sound mapping of Ecstasis *at the Biennial of Electronic Arts Perth (BEAP), John Curtin Gallery, Perth. The joysticks seen in the images were used while technical issues with the head-trackers were resolved.*

Image 27: SoundSites *at Span Galleries, Melbourne*

This image was taken from the front of the exhibition space. The panels can be seen illuminated under downlights along the walls. In the lower right corner is pictured the edge of a table with headphones made available to gallery visitors on arrival.

Conclusion

Formal analysis and technical descriptions are standard topics of electroacoustic literatures while broader reflective analysis of making is less common. A way of establishing the distinction between making and production, is to reflect on intangible influences on the project, such as how time unfolds over the course of the project; managing progress against a brief and milestones, managing risk through archiving and observing development through progressive versions. Another indicator of the transformation in my practice can be observed through an expansion in the places of making and presentation, in part, facilitated through the technological platforms now available to produce spatial sound designs in diverse milieux, and the improved acoustic conditions of the spaces where that practice is undertaken.

During the transition from artist to design researcher in a school of spatial studies, my awareness of making was shaped by daily contact with practitioners whose field of practice is objects, images and spaces. Through this contact via lectures, tutorials and seminars, to ad hoc conversations and collaborative project meetings, I formed a position on the distinction between composition and sound design. Where composition is primarily concerned with discovery and sustainment of an internally consistent sound world, the practice of spatial sound design demands a focus that encompasses the external issues as described here, and the internal qualities of the work as expanded upon in the next chapter.

4.0 Auditory Spatial Qualities of the Electroacoustic Projects

> *Auditory space is very different from visual space – we are always at the edge of visual space, looking into it with the eye. But we are always at the centre of auditory space, listening out with the ear (Schafer 1991, p. 121).*

Introduction

The inversion of perceptual attention described by Schafer is fundamental to understanding spatial sound design. Once a sound is positioned at a stationary location, or dynamically around the listener, and combined with sounds also positioned either statically or dynamically, the listener is presented with an aurally complex field of attention-forming components.

In this section, I identify and analyse key techniques, underlying concepts and creative motivations for particular spatial sound designs. That is, the positioning of auditory materials in space. The selection of particular physical objects and events for recording of sound materials, and their transformation using digital signal processes is a central part of my electroacoustic works. After first discussing several examples of the relationships between source sounds and their transformations, I move to consideration of techniques for distributing these materials in time and space. In the third part of this chapter, I draw on these two activities as the basis for intended auditory spatial qualities from these design moves.

4.1 Sonic materials and material transformations

K*: the minimal sound of psychological dominance*

The production of *K* is dominated by an 'algorithm' sound. It is a 300hz sine tone, split over four channels and modulated at eight and ten hertz. The sound is present in four loudspeakers around the audience, panned in such a way that it appears to emanate as a virtual audio source. The boundary between listener and the space of the dramatic story is dissolved. My intention is to create an interior environment within the listener, immersing them in a psychological space with no possibility of escape. If the listener turns their head attempting to locate the sound source, it 'shifts', or spins, appearing to be equally located, or present around the listener.

Sound example 25: K *versions of modulating tone*

Sound example 25.1 (Software-startup_tone) appears at the beginning of K's interrogation. There are two sounds to this event, the processed band saw followed by the modulating tone of the software sound. A sub-patch in Max/MSP was used to achieve the cross-fade from sound file to electronic sound as heard here. At different times during the interrogation, the character of the Chief Officer allows the software sound to be turned-off, which is a sound cue. On its return (the officer has prop representing a software remote control), it was necessary to give a small jump in amplitude to the software sound so the actor could jerk his body as if the tone were re-entering his nervous system. This was achieved by using an envelope with a 'spike' in it, followed by a steady amplitude value. Sound example 25.2 (Software-sound-version-2) shows the re-entry sound. Sound example 25.3 shows the unmodulated then unmodulated versions of the tone.

The tension being played out in the body of the actor is also conveyed in a subtle way to the audience. The tone first appears at a very low volume. However, its continued presence and irritating fluctuation as demonstrated in Sound example 23, is intended to create a tension in the listener in part caused by the psycho-acoustic effect of having to suppress one's attention from an omnipresent tone to concentrate on the space of action and dialogue. The sound begins with K's presence; it is linked to him and provides a vehicle for the journey of his character. During the closing sections of the play, the sound increases in loudness, dominating the entire space and fluctuating K's body in disturbing spasms.

The modulation of the tone not only provides the actor with a physical action to connect with, it avoids the tone becoming aurally redundant and failing to achieve an annoying presence. At a few key moments in K's detention, the tone stops, becoming a threshold marker between the states of interrogation, and the state of psychological release. The affect on K was palpable. As listeners, we have also been subjected to the insidious presence of the tone for over ten minutes of action-time, and are similarly released from the mental effort of having to suppress continued interference to our aural attention. In the large, highly reflective space of the Touring Hall at the Melbourne Museum, the reflections and nodes caused the tone to noticeably shift pitch in the room, creating a secondary layer of sound. I recall that other crewmembers loathed the sound, which in the context of the play, was an affirmation of its affect to create an excessively unpleasant situation in an understated way.[86]

Ecstasis - the head-tracker sound or sound of least intervention

The final solution for the head-tracker mappings in *Ecstasis* was to use a sound with minimal presence in the space. The head-tracker data modulates settings on resonators that are fed the output of a single noise generator. The result is a gentle wispy stream of noise, similar to

86 During an artists' talk at the Seoul Performing Arts Festival, 2005, a Korean student observed that the 'K' tone, reminded him of a series of auditory study aids used by Korean students. These tones are intended to help students study when they are tired, or can't concentrate. Even something as abstract as a modulating sine tone might have widely divergent cultural referents.

wind through pine needles, or humming of fencing wire on an open plain. To ensure a complex mellifluous stream of change in each audio channel, the eight resonator channels, each controlled by different head-tracker mappings, converge on four *VBAP*s, also modulated by unique heading and pitch mappings. An example of the final head-tracker can be heard in Sound example 18, and described in the caption on page 109.

The use of this sound is in part a response to the disruptive acoustic conditions created by the projection system in the VR Centre. The noise bands appear and recede into the unremitting whining and howling of the Barco projectors. They trace rapid trajectories around the space, while undergoing dynamic changes in timbre caused by the processing modules. Where the noise from the projection system is a classic flatline, highly redundant sound, this head-tracker layer activates the space with an energetic presence. The spatial and timbral changes to the sound articulate the eye scanning processes played out through the small motions of the viewer-listener. Furthermore, I wanted a sound that conveyed a strong sense of movement to the listener. Where *Ecstasis* is about human presence in digital environments, the quality of this auditory presence might be understated, or barely perceptible.

The head-trackers used in the project were developed for high-end military type simulations. The response of the devices was very fine, producing a data stream to at least four decimal places. An unexpected outcome of this accuracy was the degree to which the head could then be used for fine motor skill type control, whereas it is usually the hand that is considered the appendage for accurate gesturing. At the time of the *Ecstasis* project, I attended a Melbourne performance of the Arditti String Quartet, and was reminded also of how expressive and responsive head-motion can be in musical performance. As first violinist for the Quartet, Irvine Arditti's small sharp cues for the players were sufficient to keep the ensemble together throughout a virtuoso performance. One might also note how meaning is silently conveyed to a speaker, or across a room by the position in which a head is held. These observations of the accuracy, subtlety and expressive potential of head motion inspired me to seek a subtle solution to the type of sound and mapping for the head-trackers.

Ecstasis – the piano as sound source, and an internally consistent environment

Metraform developed the *Ecstasis* project along several simultaneous lines. These included visual and sound design, development of an interactive model, spatial design of the virtual environment and a data control and modulation software system. During development, we would test and workshop current ideas and work in the VR Centre. The sub-vocalisation or internal listening process I describe at the start of *Section 4.2 Spatial sound design techniques* on page 166 was critical to defining the final acoustic environments for *Ecstasis.* As design of the virtual environment emerged, thematic visual elements of modulating lines, points, and volumes in flux became evident. I finally settled on two principles for the selection of sounds that would be used in the project; use of as few sound types as possible - and ones mainly from piano recordings, and all processing was to be real-time. The aim of the first point was to imbue the acoustic environment of *Ecstasis* with an instrumental quality and maintain an internal consistency of timbre. The effect was intended to be as if the entire virtual environment were a single musical instrument transformed through the interaction of spatial data from the visual environment (intra-active data) and gestural data from the head-trackers (interactive data). This sense of performing an instrument, although not an overt aspect of the work, was in part suggested by the quartet of audience members who were to drive the work via their combined head gestures.

Recognition of the source sounds underlying the work is not critical to the experience of *Ecstasis*, however a brief description of the sources helps describe specific features of the final acoustic environment. The sounds collected from extended performance techniques applied to a piano, then subjected to further processing have a rich resonance and pitched quality imbuing the acoustic environment at times, with an instrumental-like quality. A piano is not only cable of producing pitched sounds, but also a plethora of sounds generated from non-conventional means such as tapping and scraping the casing, strings and body of the instrument. While the pitched sounds of the piano yield conventional musical material, the remaining techniques produced a sophisticated array of sounds. Other sources are starkly contrasted to these and include collections of shells and bamboo chimes selected for their complex textural possibilities. For the most part, sounds themselves are not treated prior to their use in the work – all appear 'dry' and unprocessed. It is possible while *Ecstasis* is playing to mute all processing modules, and hear the skeleton of the work, the original unprocessed recordings of sounds from a piano (see Sound example 26: *Ecstasis* original sounds and processing). The reason for making all processing real-time was related to maintaining a robust gestural quality to the sound design. The processing was designed to respond to different data streams, including those from the head-trackers and the environment itself. This sense of responsiveness was a critical part of the project, necessary to closely engage the audience with the physicality of the virtual spaces. Audience members should strongly sense that their presence was in some way registered in the work. Linking this to the audio processing ensured a sensuous effect would be created when gestures were linked to sounds that were highly processed and spatialised. These mappings often caused detailed changes in pitch and amplitude, which, in traditional music performance, are associated with nuance and expressiveness.

Sound example 26: Ecstasis *original sounds and processing*

Sound example 26.1 is taken from the middle section of the composition layer at 609 seconds. The main sound in this text is a glass sample. The real-time processing includes 16 delays set 100 milliseconds apart and distributed to 8 different spatial locations around the listener, 4 separate amplitude modulations of between 1 and 32 Hz controlled by 2 envelopes, and a six second reverberation time in SPAT[87] *emphasising longer decay times for frequencies around 136 Hz. The processing is applied to the sounds between 41 and 93 seconds, then again between 2:08 and the end at 3:09.*

Sound example 26.2 is taken toward the end of the composition layer at 715 seconds. The low scraping is a shell sound pitch shifted in real-time, sent to the tap delays where each delay is set 15 milliseconds from the previous one. The outputs of the delays are sent to a single VBAP then later to VBAPS slightly separated to 'smear' the effect around the listener. The piano sound is being pitch shifted by values generated from the stochastic arrays causing dramatic changes of register. The processing includes GRM Pitch Accumulator and Shuffle VSTs along with SPAT reverberation. Some original samples were pitched shifted for lower frequency content.

Creating the palette for Canopies: chimerical acoustic environments

Where the *Ecstasis* sound world is aiming for an internally consistent organisation around a limited set of timbres, the *Canopies* palette is a broad one. The sound sources for *Canopies* were selected for an individual richness that was likely to engender complex sounds when processed. These included a set of wood chimes, a collection of shells, a set of beads, a bundle of small bamboo sticks, water droplets, small brass bells, finger cymbals and vocal improvisations. The only other source was purely electronic sounds. The processing of these source sounds was primarily through *Audio Mulch.* In 1999, this program was available on the PC and was robust. I used the program to process previously recorded objects as well as improvised vocal performances in the Level 7 Studio, Building 8 at RMIT University (see Image 21).

A guiding principle of the design for this project was to use sounds with mid-to-high frequency ranges (400 - 8000 hertz) therefore physical objects were selected for recording that produced frequencies in these ranges. I also sought extreme contrasts and textures that were not likely to exist on the Southgate site from the low frequency sources previously identified as dominating the on site soundscape.

The use of a palette of sounds in an installation, or automated work like *Ecstasis,* has an interesting relationship to a composed work. In the latter, the composer makes all the selections of material that will then be fixed in time in the final version of the work, as is the case in all the *Symbiosis* chambers and *Canopies: concert version.* The way selection is undertaken in an installation, or automated work is via code with varying levels of control from random to selected sequences, thus the role of composition here is in one of automating the selection process. Hence, several versions of the work can be extruded from the same material. While the

87 SPAT is short-hand for - *Le spatialisateur*, a sound processing module from IRCAM.

permutations are not infinite, they are very large in number. The palette for *Canopies* is listed in the next table.

Palette sounds (names are from original file structure)	**Description**	**Number of variation files per group**	**Combine with…**
Bells and Cymbals	A series of metallic structures.	4	High Dense Flock
Calls_1	Gestural gritty, mid range calls.	7	[no notes in work book]
Calls_2	Gestural granular type calls, higher pitched than Calls_1.	30	[no notes in work book]
Cascades	Metallic bell chime textures with descending qualities and tones.	12	High Dense Flock, Dust streams (ppp)[88] [From] Falling
Descending Bells**	Metallic sounds, *glissandi* via moving pitch shift process on tail of sound, sharp attack preserved.	19	[no notes in work book]
Dry-Brittle-Masses	Textural sounds granulated, mostly dry, but some pitched from bells.	35	[no notes in workbook]
Dust streams	Environmental, wind-like noise streams with dynamic filtering effects.	19	Cascades, Flow_textures_3
Dust_textures	Related to the 400-600hz tone, gestural sounds, but used to build complex textures, as a flock type mass of sounds.	9	Flurry
Flow_textures_1	Gritty processed sound with Rissett-type filter, different frequency bands spatialised in file; internal detail is fast.	10	Woodchimes_low.lo-op
Flow_textures_2	Metallic, slow chime-like sound, but with sustained qualities, intimates motion caused by wind on suspended objects.	26	Flow_textures_3
Flow_textures_3	Similar to Flow_textures_2, but with other processing for variations. Similar pitch qualities.	31	[no notes in work book]
Gritty_chimes	Delicate pitched metallic timbre with wavering rhythm. Some granular qualities also.	13	High dense flock
High_dense_flock	Ascending and descending motions with traces in some files of the 400-600hz tones.	11	Gritty Chimes
Organic_Signals	High frequency click-like signals, could be insect or electronic in nature. Some files with reverberation for distance effects.	13	[Organic] Signals Reverb 1, 2, 3
	Total number of files:	239	

Table 21: Canopies chimerical acoustic environments *palette*

88 ppp = musical short-hand for 'very soft'

The 239 files of the work range in duration from 0.09 seconds to approximately 1 minute 30 seconds. This table was generated from workbook notes also shown in Image 6, on page 79.

The first column contains the name I assigned to the group of sounds.[89] The next column has a general description of the qualities of sound, and any specific features. The number of variations indicates the number of files per group, and the final column is constructed from work notes, where I determined which files from different groups might be combined on site. The duration of sounds in the palette ranges from 0.09 seconds (2ATTACK1.aif), to 94 seconds, (High_brittle_chimes_3.aif). Much of this material was improvised in the studio with the results being recorded onto DAT, which immediately generates an archive of the studio session. This was then loaded back into the PC for further auditioning and editing. The process of creating and processing sounds in real-time also gives many of the groups in the palette a sense that the sound has been crafted, or fashioned through gesture.

The palette evolved during studio sessions over the summer of 1999 - 2000. I had general ideas that would inform the making of groups, for example, that the sounds should have highly contrasting qualities to sounds already on the site. As with *SoundSites* which had just been completed, the acoustic environment provided inspiration for different sound types. One example would be the shells that were the source sounds for the 'Gritty Textures' group above. Around the time of making *Canopies*, I was spending weekends away from Melbourne by a beach peppered with small dry hollow shells. Most Australian beaches are covered in fine white sand, so this aural-physical texture was unusual to someone raised in traditional beach enviornments. Walking over shell-covered surfaces produces a smattering of small clicks and deeper more resonant 'skrunch' sounds as the shells are compressed underfoot. I collected a box of shells to record in the studio in Melbourne. Other groups such as 'Calls_1' and 'Calls_2', were to suggest that the listener was immersed in a field of communications, or signals. The idea was that the signals and calls would be located somewhere between 'micro-radio' transmissions and insect like territorial communications. The 'Flow_textures' groups appear to have an environmental agency at work in crafting their sounds. These sounds appear as if they were being forced around the site as textures that evolved through cyclic energy flows or waves, not with any particular direction, but a recurring waxing and waning of an undercurrent with perceptible waves and troughs. In contrast, the 'Cascades' group has distinct pitch elements and a stronger sense of direction, usually descending motions with an expansion and contraction of internal motion in the sounds, which could be described as a 'flurry', as opposed to the 'Flow_textures' gradual unfolding.

Although it was possible to combine groups, there were technical issues that I resolved by making sub-mixes of material. The duration of the sub-mixes was up to 73 seconds. There are two pages of site notes in my workbooks for directions on making these sub-mixes. The first notes were made during the initial installation of *Canopies* on Friday the 14th January 2000 from 11:30 am. Diary notes specify "Studio" on Sunday the 16th January, indicating a session for

89 These folder/palette names appear in the presentation materials for a talk given on September 11, 2003 at Deakin University's School of Architecture and Building, but not the site notes in the *Canopies* work book.

remixes following the Friday installation process. The next entry indicating a second visit is "Nigel S'gate"[90] on Friday the 4th February at 11:00 am. This is when the new material was most likely integrated into the previously installed sounds. My work notes for *Canopies* also indicate a folder containing a notation that silent sound files were needed. To insert pauses in the cyclic palette, the soundscape system had to select actual files and play them, although they were empty of any audio content. I created a sequence of files that were of 1, 2, 5, 10, 20 and 60 seconds duration. By placing individual, and copies of files from this sequence together, any duration of silence could be created (see Image 6, page 79 for work book scans).

There is one final point to make about the transition of listening to these sounds between the studio and the site. Sounds that I had initially imagined- in the studio would be too strident worked well on-site, as they clearlydisplayed sufficient contrast or attention- focussing elements to stand out against the city soundscape. Others were surprisingly effective. I observed people's reactions on site to the descending bells, which caused some to stop and look out over the horizon. Even on this external site, adding reverberation to the sounds gave the impression that the sound sources were well beyond the immediate boundaries of the soundscape system.

Sound example 27: Canopies *examples of sounds*

Sound example 27.1: Calls_1, an example of a rasping like call. Sound examples 27.1, 27.2 and 27.3 from the Calls_2 group demonstrate the dynamic interplay of this group between speaker channels evoking some type of call-response situation between species. Sound example 27.4 and 27.5 are two closely related variations from the Cascades group, while Sound example 27.6 and 27.7 from the Flow_textures are contrasting in motion and overall spectral content.

Canopies*: concert version: extending the palette*

The concert version of *Canopies*, based on the sounds of the original installation, is in part a re-reading of the first project. Not only is it based on the same material, but the form of the work is similarly structured on a series of timbral pools; distinct sections based on one or a few sounds. Sections gradually merge into each other, as if the listener has moved between zones on the original installation site, where foreground and background material are balanced differently in the two locations. As the concert version would be performed indoors as opposed to the urban precinct of the installation, it was feasible to re-craft some of the original material with finer details.

The most significant addition to the previous *Canopies* sound world is the opening section of the concert work. I sought a dramatic spatial dialogue of sounds announcing the work, and to establish a dynamic presence in the performance space. The listener is immediately plunged into an acoustic environment dominated by sounds propelled around the listening space. As in the original installation, sounds are predominately in the mid to high

90 Short-hand for Nigel Frayne, Southgate.

frequency ranges as they were in the installation version, but they have been transformed using synthesis techniques which considerably altered their pitch and amplitude envelopes. This is most evident in the 'Signals' and 'Calls' group, where the sounds transformed via cross-synthesis techniques have very dynamic shifts in their timbral envelopes but do maintain qualities of the original source sounds. The idea was that the 'Calls' should fuse, or merge.

The penultimate section of *Canopies* is a similarly spatial dialogue between closely related sound types. Reminiscent of the 'Calls' group, but also suggestive of a dulcimer tone, the sounds of this section have a number of significant components that support the spatialisation of the work. After a short transition from the previous section and a chaotic massing of sounds, the section is firmly established by 10:08 and lasts to 10:40. The main sound has a distinct double attack, a rapid-sliding gesture with small pitch shift. The strong sense of pitch is necessary to give the listener an added cue to locate individual attacks during a sound diffusion performance. By panning between individual and groups of loudspeakers, particularly ones separated by larger distances during the slide component of the sound, it can be made to appear to travel around the space. Even if there is little or no panning between loudspeakers in this section, the sound can still appear to move between different locations due to the panning embedded in the mix. It is also possible to set-up exchanges that have distinct start and end points in space, supported by the strong attack of this sound, which instantly takes the listener's attention to that location.

4.2 Spatial sound design techniques

> In my imagination I flooded the space around me while walking through it. I lived in a sort of invented immersion in which I moved about in the heart of a fluid, luminous, beneficent, dense matter … (Diolé, p.118, quoted in Bachelard 1994, p. 207).

> There is no non-spatial hearing. The auditory event may be located in front of the listener, inside the head, or spread in the environment (Blesser 2001, p. 886).

My initial auditory imaginings are soundless. It is as if I can determine, or sense the spatialisation and the sounds without reference to the sounds themselves. Sub-vocalisation is a necessary skill developed to varying degrees by score-based composers and musicians. It is an ability to 'hear', or conjure in one's aural imagination, the sound of individual instruments and their combinations into extensive orchestrations as represented by a printed score. The skill can be equated with the process of learning to read the written text, where the child first reads aloud, then more frequently to themselves as their aural memory develops to such an extent they may silently recall the sounds of words without having to hear them first vocalised. I use the invented term *aural eye*, as personal shorthand for a process of looking and internalised listening, of translating between a visual field and engaging the aural imagination. Ihde (Bull & Back eds. 2003, p. 61) uses the term *auditory imagination* to discuss inner auditory experience familiar to musicians and composers, but one that focuses purely on music and sound and not its intersection with the visual experience of the world.

With particular compositions, I conceive sound as a surface, a veil, or terrain over a substratum that is the actual composition, which is energy distributed in time. When 'looking' into a visual field, static or dynamic, for the purpose of realising an allied sound design, this soundless sub-vocalisation becomes a means to unearth this energetic substratum. I experience this *a priori* sensation of sound as a highly physicalised one, where sound(s) appear within my imagination, embodied with particular qualities such as weight, presence, rugosity, or turbulence. This conceiving of the work also happens in imagining the spatialisation of a work, where I find it possible to disengage a projective spatial arrangement from potential sounds.

In the previous sections, I have built a picture of the issues of making the projects, describing the techniques involved; the places of making and presentation, the material and material transformations on sounds, as well as the project logistics, or unfolding of the project over time. As a framework, I will now re-draw through this, to a final section on the qualities of the spatial sound designs. The qualities described here, or the qualitative aspects to the projects, arise out of the ensemble of techniques, technologies and processes discussed through this chapter.

On what element do I intend the listener to focus as a result of the spatial auditory design developed and delivered through the technical and technological endeavours discussed above? Initially, this is a change in the aural qualities of a space. This may be related to a virtual environment as in *Symbiosis* or *Ecstasis*, an urban environment as in *Canopies*, or the change in emphasis from visual experience to aural in the case of *SoundSites.*

While the quotidian auditory experience of listeners is stimulated by sounds circumambient to them in the environment, few cultural experiences provide listeners with a surround, or auditory immersive experience. The processes of composition, of organising sounds into formal relationships through time are expanded in spatial sound designs. Spatialistion of sounds demands that the composer/designer not only determine the temporal relationships of organisation, but also their spatial relationships.

The theories on space in electroacoustic music discussed in Section 1.0 are analytical posits arising from composition and design of spatial works and the engagement of composers with materials of an auditory discipline. This body of theory was produced through electroacoustic music practice in close engagement with making by practitioners as opposed to theoretical speculation by non-practitioners. The endeavour in this section is similar, detailing a series of reflections on my close engagement with sound in the electroacoustic studio and places of presentation.

Layers revealed

In several of the following sections, the techniques used will refer to 'layers'. In Chapter 1, I noted that Bregman's theory of the auditory stream was influential on my thinking at the time of *Symbiosis.*[91] A layer conforms to Bregman's definition of a stream, which "serves the cause for clustering related qualities" (Bregman op cit, p. 10). For example, in *Landscape* of *Symbiosis,* three of the sound types that appear and recede to the listener at different times, come together between 1 minute 42 seconds and 2 mins 32 seconds, comprising the prescient low travel sounds, high rasping metallic and a less intrusive chord cluster. In *Still Life* climatic moments are built by an increased intensity of the low-pitched breath cycles, the presence of high-pitched metallic sounds, the rhythmic punctuations of the drip sounds and swirling timbres in mid-range frequency. (See Sound example 28) I prefer to maintain the distinction between layer and stream, as the latter is a perceptual phenomenon, and layer is a production technique.

In *Symbiosis* layers are differentiated in space, timbre, and usually a relative frequency range that is low, medium or high. Absolute or relative pitch ranges are particularly useful organising parameters for layer organisation due to human sensitivity to frequency compared to other sonic parameters.

Sound example 28: Symbiosis *sound layers*

Two examples of different layers in Symbiosis. *Sound example 28.1 is from the opening of* Nebsphere, *and Sound example 28.2 is from* Still Life *starting at 2 mins 48 seconds.*

Embedded spatiality

In *Canopies: concert version*, I explored a technique of using simple gestures to build successive sub-mixes. These submixes display such strong gestural characteristics I would go so far as to consider them as complex spatial micro-compositions. The spatial motions – in the case of *Canopies: concert version* – are built from two of the three spatial parameters available in a stereo format, that is, position between left and right loudspeaker locations, and perceived distance, simulated by amplitude effects and presence, or absence of high-frequency content. Reverberation, the third spatial parameter available in stereo production was not widely used in the opening sections of *Canopies* discussed here, but appeared in later sections of the work, and also throughout *Ecstasis.*

Sound example 29: Canopies *embedded spatiality*

This audio example is from the opening 34 seconds of Canopies*:* concert version*. Each sonic object marked in the line score reduction of*

Figure 20 was built from an early submix with unique spatial characteristics such as panning or amplitude roll-off for distance simulation ensuring that a complex of spatial motions were embedded in the final work.

91 See Chapter 1, *Defining auditory terms, models and associated practices*, page 34.

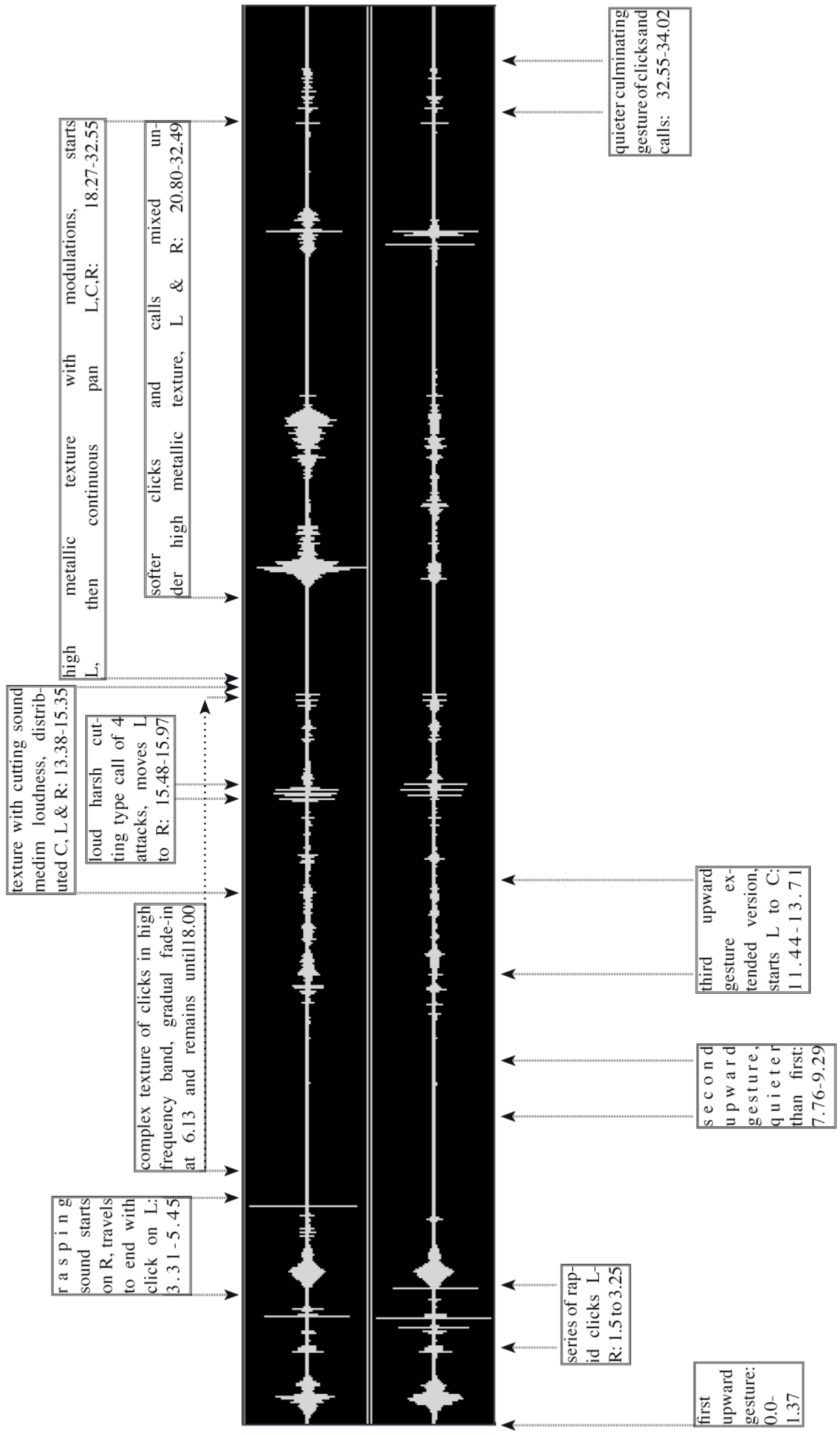


Figure 20: Canopies *embedded spatiality*

Each text box describes one of the 11 primary submixes in the first 35 seconds of Canopies*. See Sound example 29:* Canopies *embedded spatiality. The layering of these submixes and their independent spatial locations gives the work its dynamic qualities. All time indications are in seconds to two decimal places. For purposes of visual layout, the following letters are used to indicate panning locations: L = left, R = right and C = Centre.*

The panning and other effects are occurring at speeds that would be impossible to achieve in a performed diffusion, or would require large amounts of data to be automated in real-time. Each individual sound component of the micro-compostion would require its own data control. The technique is intended to create events that are very dynamic, dramatic and present complex spatial motions to the listener's ear. Furthermore, as *Canopies* is to be diffused over many loudspeakers, the resulting sound events themselves are to be positioned in many different locations, making the performance of the work the final stage in its realisation through a translation from the two-channel stereo version to the many channels of a diffusion version of the work.

A rule of three: multiple layers in spatial sound design

The act of listening is not a passive process of reception. The listening attention of an audience will roam around the auditory materials of the work. A surface texture, or single layer would not suffice to carry the work where multiple layers of sound would achieve this. In *Canopies, Symbiosis* and *Ecstasis,* I was concerned that listeners be afforded a rich auditory palette through sound transformation producing a surface that engages listener attention on short time scales. The number of layers is significant. Too many layers are likely to saturate both the listening space and attention of listeners. While saturation might be a desired effect in a given situation, it has unintended consequences if not handled carefully. I have found that once layers of complex sound are built up and distributed in space, a rule of three applies. Three layers, distributed in space either statically or dynamically around the audience, create a complex arrangement of up to seven different listening scenarios at any time, as shown in Figure 21.

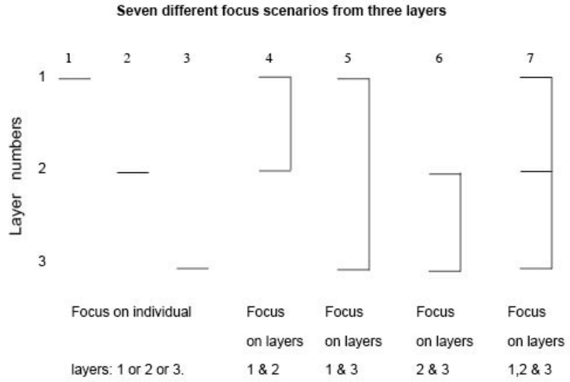


Figure 21: Rule of three

Three layers provide up to seven different combinations of individual and grouped layers for the listener. The listener might focus on a single layer (scenario 1, 2, 3), layers 1 and 2 (scenario 4), layers 1 and 3 (scenario 5), layers 2 and 3 (scenario 6), or all layers simultaneously (scenario 7).

Sound example 30: Ecstasis *rule of three layers*

The scenarios are form creating, transitioning between scenarios allows a sense of partition, or sectioning for extending compositions. The line score reduction in

Figure 22 shows the movement between different scenarios.

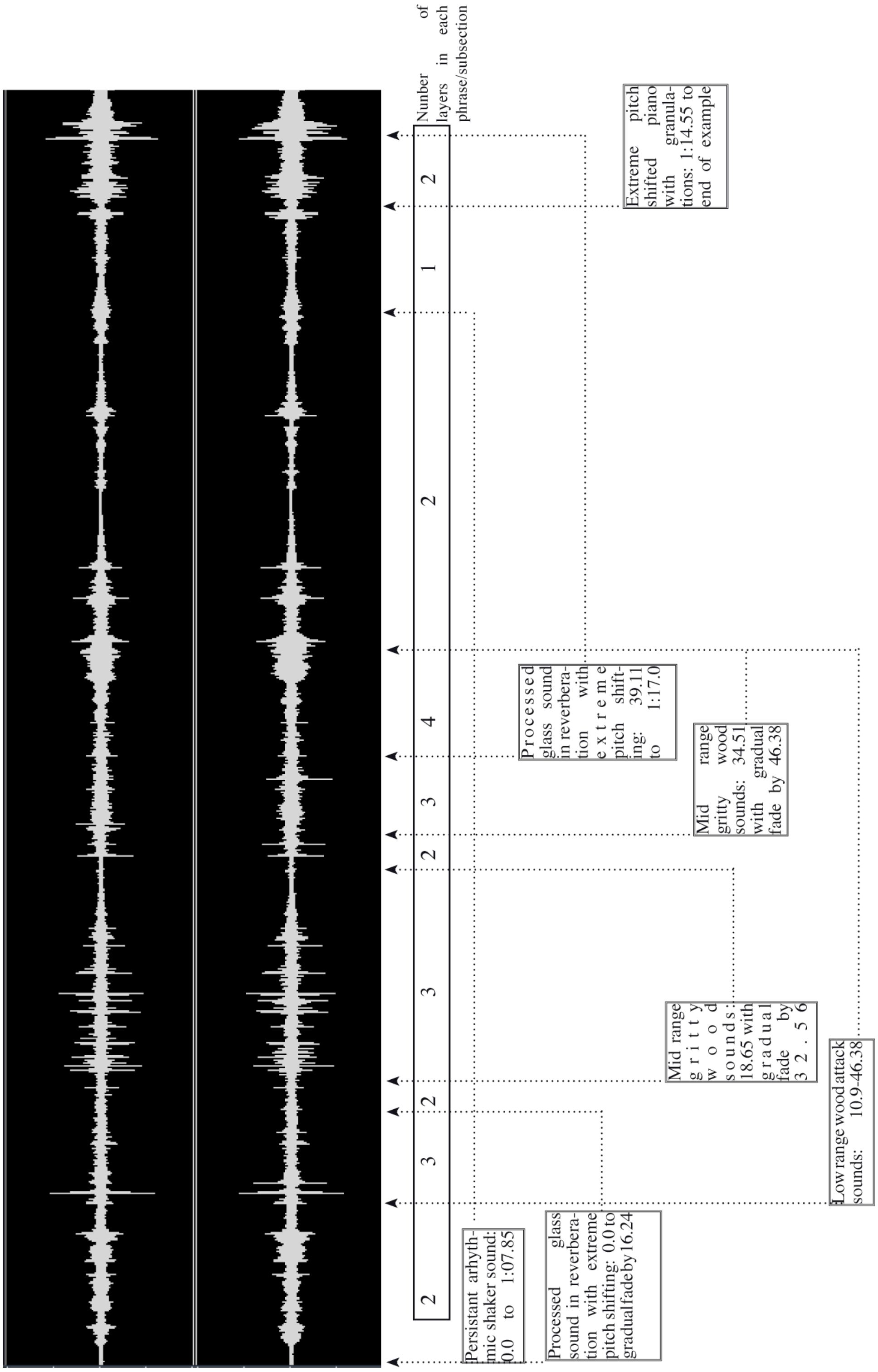


Figure 22: Ecstasis *example rule of three*

This example, taken from the middle section of the Ecstasis *composition layer starting at approximately 540 seconds, shows how different layers are organised. The text boxes describe the layer and show the start and end time in minutes and seconds to 2 decimal places. The number of simultaneous layers is shown immediately under the waveform. This example can be heard in Sound example 30.*

Point and plane positioning

The sound design approach developed for *Ecstasis* was to create conditions in which listeners would feel enveloped by the sound, as to extend the presence of the stereo-scopic visual environment into the physical space of presentation. By positioning sounds in particular discrete locations and zones circumambient to the listener, the sensation of immersion can be created for listeners. These locations can be derived from research in psychoacoustics of the human spatial auditory system (Blauert, 1997), architectural acoustics (Beranek, 1992), and electroacoustic reproduction (Blesser, 2001). In the works completed at the VR Centre, *Symbiosis* and *Ecstasis,* I worked with the zones shown in Figure 23, page 179.

'Point Positioning' refers to sounds positioned in a discrete location, either at a speaker, or using two loudspeakers to position in a virtual location, that is between two loudspeakers. Sounds of this type were usually short time duration, less than one second. Generally, one sound, or variations of the same sound appear at multiple points simultaneously, or with slightly delayed start times. A 'plane' refers to sounds equally distributed over a number of loudspeakers, and appearing to emanate from a plane, or surface adjacent to the listener. Where short sounds, for example, those with duration of less than 0.75 seconds work well for point positioning, longer sustained sounds work best for creating the sense of a plane of sound.

Weight and temporal form of material

In making these spatial sound designs, I found that once audio materials are placed in a speaker configuration other than stereo, the amount of material required is much less than with other forms of electroacoustic composition. In a stereo field, once a sound appears on the 'stage' of the work, and a spatial identity for it has been established as static, foreground or background, or following some spatial trajectory, then little else remains for it to achieve spatially. The limits of the two channels are such that the sound has very little space in which to inhabit or play out a narrative. In a spatial sound design, the expanded possibilities for a sound's spatial location are such that a sound might also occupy the listening space for much longer, appearing in different locations, guises, or strategies. This spatial narrative is also part of the sound's identity in the work. This implies too that in a spatialised work, the amount of material required is potentially less. The longer individual durations for which a sound might occupy the listening space, means that less sounds are likely to be required for the whole work.

In *Symbiosis*, several of the individual pieces have a formal structure where all sounds of an eight-minute soundscape, are introduced within the first minute. This means the material of the work is always present to the listener. I liken the effect to one of a mobile suspended in space. The material revolves through the temporal organisation of the work appearing and reappearing, and also in different spatial guises and strategies. This gives the work an internal consistency of timbre, but one of subtly changing form as different sound layers come into contact with each other.

Monophonic spatial distribution and counterpoint

A section comprised of many different sounds is classified as 'multi-voiced polyphony', while one comprised of single sound type, possibly with minor variants but distributed around a listener is 'multi-voiced monophony'. In this type of scenario, the listener is surrounded by an homogenous timbre, where the effect might be similar to being in a natural environment of a colony, or swarm. This formal device is related to the layer type 'rule of three' shown in Figure 21 (page 171) and provides a sense of repose from other sections based on exchanges of many different stypes types in a way that constantly demands attention. A spatialised exchange between sounds is maintained in which a single texture envelops the listener, rather than the listener being located at the centre of an environment of differentiated sound objects.

Sound example 31: Two examples of monophonic timbral distribution

Sound example 31.1 (Ecstasis-glass-monophonic) is a 48 second section predominately of glass sounds, just prior to a series of interjections of other timbres. Sound example 31.2 (Backface-gongs-monophonic) from 1 minute 17 seconds. This example starts where other sounds fade from the work and the gongs are solely present until 2 mins 40 seconds.

Intra-onset times

As the psychoacoustic system of a listener determines the spatial location of a sound source by calculating the time difference of a sound arriving at the two ears, using small time differences in the attack portions of stereo sounds enriches spatial sound information. The effect created is one in which the small delays can either confirm or disrupt the actual spatial information, either clarifying or blurring the localisation.

Sound example 32: Canopies *intra-onset times*

*Sound example 32 (*Canopies*-intra-onset-times), shows how attacks appear close together in time, but separated between left and right channels. Marked on the spectrogram are key attacks on both channels. Note that due to scaling issues, the image and audio are not precisely time aligned.*

From the Author's perspective, the quality produced in a sound from intra-onset time manipulation exemplifies a critical difference between spatial auditory design and simply spatialising sound. The latter is a process of panning sound over multiple loudspeakers, and could be achieved with sound or music previously made for stereo, or instrumental performance. Auditory spatial design embodies a different set of intentions to sonic materials. It is a design process whereby the simultaneous application of techniques to a project will enhance the spatial auditory experience of listeners.

Although I have discussed techniques used throughout the projects and exemplified their application in specific instances, it is their simultaneous application that is critical. Stein and Meredith's (op cit p. 83) observation that auditory spatial perception is based on computation is a succinct clue to a critical aspect of spatial auditory design. It is not simply the positioning of sounds in space that defines spatial auditory design. It is the temporal design at work in the project also. Unless the ear is presented with a plethora of events distinguishable through their temporal identities, redundancy will quickly result. It is the subtle synthesis of these techniques that is the aim of spatial auditory design.

Envelopment

The setting for *Symbiosis* and *Ecstasis* described above, along with the visual design presents an absorbing experience. Standing in front of the semi-circular screen of the VR Centre fills approximately 150 degrees of the viewer's peripheral vision. The remainder of the room is dark. While in *Symbiosis,* the virtual spaces are more like chambers in *Ecstasis* they are closer to a form of natural, or super-natural environment, constantly in flux and modulation.

Such a physically engaging and compelling visual experience could easily overwhelm the aural components of the work. Avoiding this necessitated a sound design approach with sufficient weight and aural presence to maintain a multi-sensory equilibrium with the visual components of the work. The concept and creation of envelopment was critical to establishing this presence of the soundscape. Envelopment is a subjective impression of the listener, where they experience "the difference between feeling inside the sound and feeling on the outside observing it, as through a window" (Thompson 2004, p. 320). Connections to more recent notions of immersion as used for virtual reality environments are evident in this definition of acoustic envelopment. The concept of aural envelopment arose in the early 1960s through studies of concert hall design by Leo Beranek (1992). This study revealed that the effect of envelopment is created by small time differences a listener perceives between the arrival of direct sound from a source, and what are termed the "first reflections" of sound off the room's surfaces. Lateral reflections (that is, from side walls) are of particular importance to the creation of envelopment.

A sense of envelopment in *Ecstasis* is created through the close integration of a number of compositional, physical and software resources. The audience is situated within an eight channel sound system, at all times, up to three layers of sonic material is positioned either statically and/or in motion around the listeners, and most notably, sounds are processed around the eight channels using small time differences, or delays from many locations. For example, software-processing modules were designed to take a single sound, and distribute it sixteen times across eight channels with individual time delays ranging from ten milliseconds, to around five seconds. Standard reverberation effects were also used with these delay methods. Depending on the sound source used for this processing, the effect could range from a 'smearing' of the sound around the listener, to clouds of rapid specks, or sonic points.

Interiority: Canopies: chimerical acoustic environments

The practice of synthesising or processing a sound is to design or redesign its interiority, a process sometimes referred to as 'micro-composition', and one that occupied the greatest amount of production time in the creation of *Canopies*. Where *Canopies* intersects with the notion of interiority in electroacoustic practice is through the introduction of substantially more detailed sounds than those in the existing conditions into the site's acoustic environment. A new auditory plane is opened on the site through sounds whose timbres are in the middle to high range of human auditory perception (400 - 8000 hertz) and are richly textured and varied. With no obvious visual reference on site to the external source of these surreal sounds, the listener's attention is drawn, even if momentarily, into a strange world unfolding in an otherwise ordinary urban precinct.

In electroacoustic music practice, the term 'interiority' "designates the qualities of sound that do not refer to external causes/sources".[92] It is the perceived qualities those without concern for what the sound is, or what might have brought the sound into being, for example, a hand striking a metallic bowl, or wind entangling a mesh of pine needles. When attention is drawn away from a sound's exteriority, or reference, the reduced experience can be at least as full and complicated in its own way, with a lexicon such as 'mass', 'grain', 'turbulence' used to describe these qualities of sounds, in and of themselves.

The interior qualities of a sound impart to a listener a sense of energy, both received and embedded. Received energy can also be explained as a gestural activity that brings a sound into being. Embedded energy appears to be an insertion of energy after an initial, or source sound is in motion. In his seminal paper on Spectromorphology, composer Denis Smalley proposes that the qualities of energy within a sound reveal the level of human agency related to the production of that sound (Smalley, 1997). A sound with unvarying qualities appears unnatural, in the sense of not appearing in nature, or it lacks an envelope of energy with onset, build-up, sustain and dissipation. It is the flat-line sounds of machinery and electronic devices that quickly produce conditions of informational redundancy.

In contemporary practice using software-based sound design, the interior of a sound is crafted by signal processing that is controlled directly by data either from real-time interaction, automation, or combinations of both. Real-time interaction provides one method by which traditional human music performance gestures might be mapped onto a sound, with the possibility that the sound will maintain some degree of a musically referential character. While this allows a composer/sound designer to make, for example, a more convincing string sound by 'bowing' the sound, it can also be used to create atypical sonic events such as 'bowing' a bell or flute sound. Automation allows super-human qualities to be mapped onto a sound: durations much longer than could be sustained through muscular effort or breath, speeds of

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92 Entry for *interiority* at http:// www.ears.dmu.ac.uk/, viewedFebruary 25, 2007.

articulation beyond the fifteen to twenty attacks per second possible through human muscular effort, or simultaneous changes in many parameters effecting a single sound.

Landscape

In the chapter devoted to sound landscape in *On Sonic Art,* Wishart defines one aspect of "the landscape of a sound image as the imagined source of the perceived sounds" (Wishart 1985, p. 75). The use of the word 'source' is ambiguous, meaning both 'location' and 'sounding agent'. Wishart further proposes that this disorientation and accompanying sense of strangeness is the reason why so much electronic sound was used in early science fiction films. He gives three components of a sonic phenomenon that define a sense of a landscape as aurally perceived (ibid, p. 76):

1. The nature of the perceived acoustic space.
2. The disposition of sound-objects within the space.
3. The recognition of individual sound-objects.

The soundscapes for *Ecstasis* driven by the software environment I developed, dynamically modulate the first two landscape-forming phenomena listed by Wishart, and present a myriad of individual sound objects to the listener throughout the twenty minute average duration an audience experiences the work. The stereoscopic visuals for *Ecstasis* are almost always in constant modulation with images appearing inside and seemingly outside the bounds of the screen, due to the stereoscopic projection technique. As one's aural focus in the listening moment rapidly oscillates between, and fuses all three landscape-forming elements noted above, the Max/MSP environment I developed allowed these three elements to be readily accessible during development and final run-time presentation of *Ecstasis*. The persistent modulation of sounds in the final design forms a continuum with the visuals of the work, and a transforming landscape of sound enveloping the listener continues and completes a sense of visual immersion for the audience.

Balance & symmetry

Once a sound has been placed around an audience, a type of sound stage is announced whereby an expectation is established in the listener as to the source of the sound's emanation. In the spatial sound designs for *Symbiosis*, I found that to maintain the sense of immersion, or of being in the work, it was necessary to balance when sounds appeared at different locations. For example, listener fatigue is likely if gestural sounds that draw listener attention are placed in the rear loudspeakers for an extended duration when the listener's visual attention is forward focused. Often in the *Symbiosis* mixes, sounds would enter and exit the sound stage at differing spatial locations, again so that the beginnings and endings of an event were clearly spatially articulated. By balancing the location and duration that sound events spend in different parts of the space, the listener must equally focus their attention around the space over the duration of a whole work. There are four compositional parameters for balance: entry location, exit location, location of 'body' of sound, and duration it spends in the location(s). These four parameters are similar to the ADSR (Attack-Decay-Sustain-Release) envelope of early electronic music, and describe the temporal evolution of a sound event.

During *Ecstasis*, I settled a group of eight zones of auditory space around a listener, shown in Figure 23. The diagram indicates zone limits that might be used for upper and lower and boundaries of envelopes controlling panning, or a stochastic process selecting a discrete panning location. These locations tended to be maximally separated, particularly along the front-rear (Zones 1 - 2 and 7 - 8), diagonal (Zone 3) and lateral axis (Zone 5). Placing entries of sounds in Zone 1 and 8 can blur spatial qualities of the sound, as listeners may confuse the location of sounds in these zones.

For a stronger sense of left-right separation, placing sounds between ten degrees and ninety degrees (or –10 and –90 degrees) to the listener's central location (Zones 2 - 5) will give a clearer spatial location to the sound. At ninety degrees to the head on the extreme lateral axis, sounds are unequivocally locatable. Being on the 'border' between the general locations of front and rear, Zone 5 also carries with it a strong sense of envelopment, as previously discussed. This spatial location can be used to interesting effect, as in a concert setting the fear of a sound emanating from a location that could be physically dangerous doesn't actually matter in the same way it might in the dramatic setting of a theatre or cinema. To give a strong sense of a sound being on the side to the rear of a listener requires that it be between +/– 100 and +/– 135 degrees (Zone 6). The *VBAP* settings in *Ecstasis* were often situated in these sectors. These measures can only be a guide as the physical and technological listening conditions of most spaces are compromised so that the boundaries are relative. One must be mindful however, that use of these locations is for creative purposes, not perceptual testing in laboratory conditions.

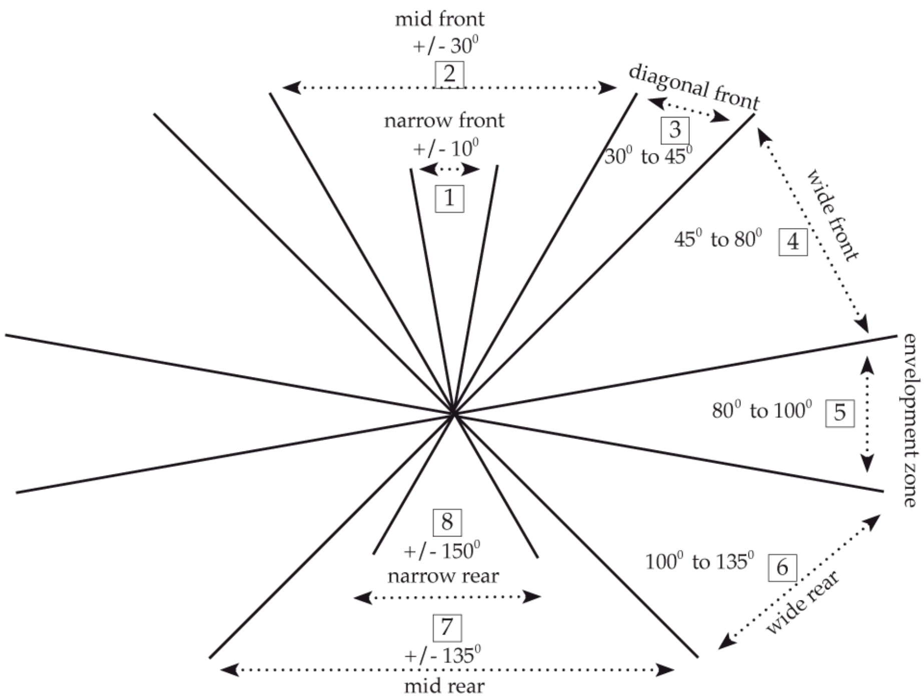


Figure 23: Ecstasis *auditory sectors around a listener*

In this figure, the listening location is assumed to be at the centre of the diagram. Zones are centre, right and rear only, although in practice, sounds are placed on both left and right sides of the listener. These zones were used for VBAP settings in either static or dynamic settings. In the latter, the values above formed boundaries for generating or processing data for VBAP locations.

Conclusion

To experiment and produce highly-crafted spatial sound designs requires specific technical resources for production and presentation. Over the course of this doctorate, the available resources both within industry and within the University for this work changed considerably. At times, the technical aspects of the projects proved insurmountable, and so provided a catalyst for the development of new solutions. My position is that the technical aspects are in fact, enabling attributes for the design processes discussed in this chapter, and for a sound designer wishing to broaden their practice, a personalised technical knowledge is critical.

A central focus of the projects is the relationship between source sounds and their transformation using electroacoustic techniques. The complexity of these sound materials is critical to the listening moment and maintenance of an audience's attention. Spatial sound design techniques must arise out of the materials themselves, and not some abstract spatial strategy. The combination of electroacoustic sound transformations and spatial sound strategies can also be analysed through particular auditory spatial qualities.

An alternative view on spatial sound designs as described here is their functioning as cultural artefacts or representations of auditory spatial milieux, either actual or speculative. As the rise of perspective representation changed the position of the viewer in the world, sound spatialisation projects may provoke changes in the status and design of acoustic environments not just in the cultural spaces of artgalleries, concert halls and theatres, but also in the everyday lived spaces of our world. In the next chapter, I turn to *SoundSites* and *CitySounds,* which investigated lived auditory experience in actual spaces, through a sound exhibition and a research project, forming the focus of the second stream of my practice concentrating on the conditions and experience of auditory milieux.

5.0 Research, and Design of Auditory Milieux

> *The conviction of the ecological psychologists is that people live out their lives in a sequence of environmental units; experience in these settings* is *life* (Gump 1971, p. 134 Italics are Gump's).

Introduction

Throughout a day in an urban environment, we traverse a plethora of acoustic environments accumulating auditory experiences.[93]

SoundSites and *CitySounds* are both based on a similar formal organisation, that of an episodic structure. In both projects, I wanted to investigate the listening experience of individuals that accumulates from traversing different sites within the soundscape. Most research projects and analytical frameworks such as soundscape studies or the approach of CRESSON describe the sounds, or auditory qualities within discrete environments. Truax's communicational model of the acoustic environment extends to a three-part system of listener-sound-environment. Most studies tend to focus on discrete sites rather than the accumulation that we experience of living out a day in the built environment.

For each of the two projects, I first describe the process of making and production specific to the project. In *SoundSites*, this involved a period of research and interviews combined with site visits,spatial environmental sound recordings and production. The completed form of the Exhibition is presented. For *CitySounds,* the Project was built on a virtual model and unique survey technique in a games engine. The completed project required close integration of three key design elements. The final section of this chapter uses material from both projects as the basis for observations about auditory spatial awareness in urban environments.

5.1 *SoundSites*: description of process

> *Soundscape research really should be presented in the form of a musical composition. That is the one way to bend the loop back so that research and the artistry come together and we can auditorally cross those rivers and those creeks and climb those trees and walk those paths without the academic literalism, the print mediation* (Feld 1994, quoted in Drever 2002, p. 26).

93 I am grateful to my supervisor, Peter Downton for noting the similarities between the listener living out their life in auditory milieux and the work of behaviour setting theorists. I have not attempted to apply the behaviour theory observational techniques here. However, several aspects of the theory and work of Barker and Gump's group were immediately pertinent to the concepts I was attempting to articulate. Furthermore, the wider applicability of their work in sites as diverse as churches, hospitals, a national park, government offices and retirement homes (Wicker 1987, p. 615, cited in Stokols & Altman 1987)[0], suggested the milieux concepts of behaviour setting theory might generate useful techniques for soundscape design. The episodic nature of auditory experience that I was attempting to articulate is succinctly expressed by Gump's quote leading this chapter.

SoundSites was a pivotal project marking the Author's transition from predominately arts-based work into a school of spatial studies, and a research undertaking into the broader impact that a composer-sound designer might have on and within the community at large. My creative and curatorial work at the time appeared to have reached a turning point. The groundwork had been laid three years earlier, when I took up a Winston Churchill Memorial Fellowship to attend courses at *Les Ateliers UPIC* (now CCMIX) in Paris, and study the management and operation of independent centres for electroacoustic music in Paris, Amsterdam, the UK and New York. The aim of this trip had been to gather further ideas and guidance in order to establish an independent studio in Melbourne. Part of the rationale was that other contemporary arts practice in Melbourne had a professional independent Government funded support base or production facility. Melbourne at that time supported contemporary art spaces, writer's centres, dance companies, and film and new media organisations. Yet the cultural landscape was silent in respect to an electroacoustic studio. I pursued this project for three years, coming close to realising the Centre through a partnership with a local music institution. However, by early 1999, it became apparent that the Project was unlikely to succeed in the short term, and this realisation necessitated a change of direction. Toward the end of the 'Studio Project' as it was known, *SoundSites* was funded. The Project Curator was Samantha Comte, and support was received initially, from the City of Melbourne, with additional funding from the Besen Family and Myer Foundations respectively. The Work has since been exhibited at Span Galleries, Melbourne for the Melbourne International Arts Festival (1999); the Paralympics Arts Festival, Seymour Centre, Sydney (2000), and at SOUNDplay Tranzmedia Arts Festival Toronto (2003). The primary components of the *SoundSites* project were interviews, field visits to identify recording sites or staged events, location recording, studio production and exhibition design

As the Project progressed to exhibition stage, the process elements of interview, recording and exhibition design became closely interwoven and difficult to treat independently of each other. To highlight the involvement of each component , I discuss here the formulation and role of questions, site recording, studio production, and exhibition design. The following details of the Project are used to render more objective my role in translating the experience of the blind participants into an exhibition for a sighted audience.

Original intentions

To discuss my original intentions and thinking at the time of the Project, I have drawn on four main sources of information: work notes, extensive lecture notes for presentations delivered immediately following the Project's completion, a journal article published soon after, and the successful funding applications made to support the Project production and presentation. There are two reasons for using funding applications as evidence. The first is that I use applications as logistic and conceptual project plans, attempting to capture the essence of the particular project and convincingly demonstrate the methodology of its achievement. Secondly, they are records of their time, capturing my work-in-progress analysis of the Project as compared to later examination and reflection, which would potentially be quite different. The original description of the *SoundSites* project was as follows:

> *SoundSites* is an exhibition of 25 acoustic-moments of between 3 and 90 seconds duration, created from interviews with sight-impaired individuals about how they negotiate spaces by aural means. Each acoustic-moment will present an experience of various acoustic memories, impressions, signals and environments. A range of computer-based electroacoustic techniques will be used to create these moments, ranging from traditional *musique concrète*, to transformations in the spectral domain. While some moments will present direct recordings, others will take on an imaginative interpretation of acoustic reality.
>
> (From *SoundSites* Besen Family Foundation application, May 13, 1999)

Philanthropic foundation applications usually require a statement about the need for the project which fundamentally amounts to an argument as to why the project should be funded, and what cultural, social, environmental or other issues the project is addressing. At the time, I felt *SoundSites* would speak to the following concerns:

> Because of its immaterial nature, sound is often overlooked as a critical element that shapes society and defines a culture. Yet it is a substance in which we are literally immersed in every day; the moving air particles to which our ears respond, envelope our entire bodies. Continual exposure to sound without being conscious of its effects on listening can cause a desensitised reaction to our surrounding sound world. An example of this is designers and architects who ignore the impact of their output on the soundscape, while taking great care with the 'look' of their work and not the sound waste – noise pollution – that emanates from factories and other machines.
>
> The effects of poor understanding of sound, can lead to personal harm caused by the effects of loud sounds, careless use of sound that can harm others and lead to poor listening skills. Alternatively, the conscious hearing process of listening can create a sensitivity and desire for a rich aural tapestry in which we might live.
>
> *SoundSites* will be a mechanism that responds to the need to redress an imbalance between the sight and sound of our local community. During a recent interview, a blind teacher described objects of his world as having sound and physical presence, just no colour. *SoundSites* will provide a public art event toward developing a similar awareness in the sighted community.
>
> (From *SoundSites* Besen Family Foundation application, May 13, 1999)

Interview questions

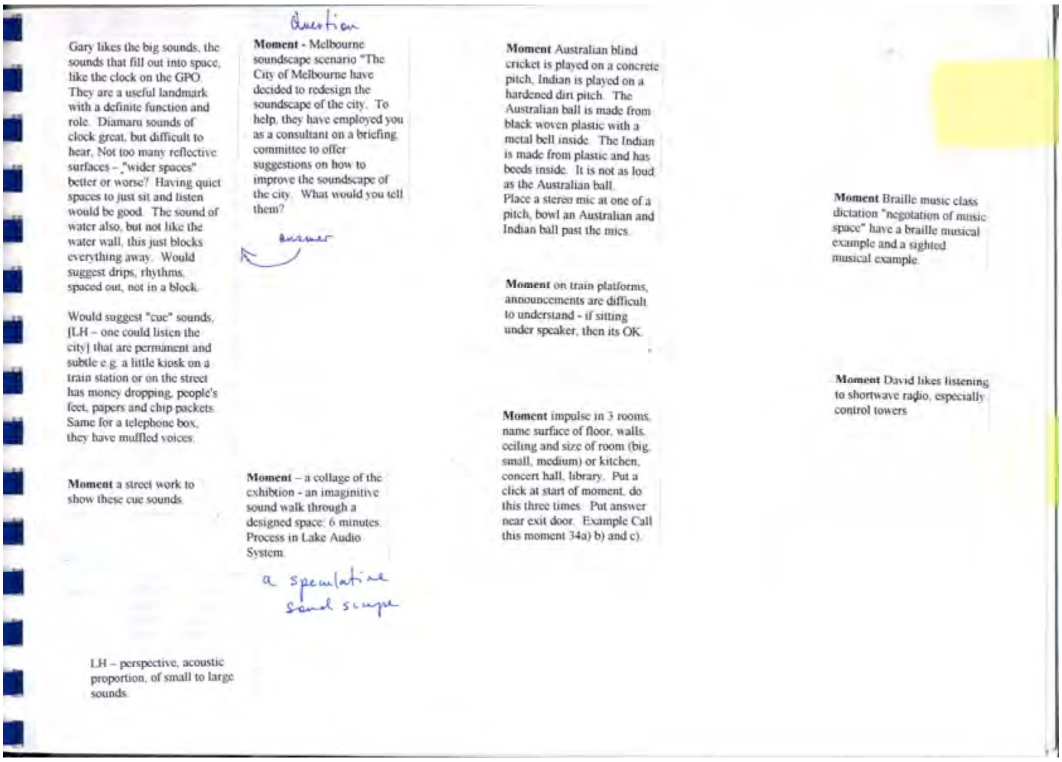
SoundSites could be considered a community-based disability project. As I will show in this section, the interview questions sought to investigate the auditory *abilities* of the blind community. Interview questions were not focussed on conditions of blindness, but on the participants' skills in negotiating physical space via auditory awareness. Another framing device for the questions was the final context in which the project would be exhibited, that is, an art gallery. Information collected in the interviews did not have to correspond to a formal methodology or withstand a process of statistical evaluation as in the *CitySounds* project. I eventually came to describe my role as creative mediation between the spatial experiences of the blind participants, and the sighted audience of the exhibition, listening to aural realisations of these experiences. In this mode, the questions are attempting to uncover translatable auditory experience. Because this process of questioning was not to establish facts, but to translate experience, I found it necessary to follow leads that might arise in a conversation, or to test ideas discovered in one interview, against experiences of another person later.

Another determinant of questions was the ability of individuals to discuss their experiences. I found this differed markedly between subjects. A few interviewees were adept at discussing their skills, and had knowledge of how sound performs in the environment. Others were experienced, but did not posses a language, or communicative skill to relate their experiences. I had to determine early in an interview how well someone was likely to describe their experiences, and modify questions accordingly. Some examples of the questions included;

- Could you talk about the sounds you find more helpful in moving around, in locating yourself in space?
- Do you find it easier to listen in some environments more than others? Can you give some examples?
- Do you find that some sounds tend to obliterate other sounds?
- Can you give any descriptions of how the soundscape has changed over the last 20 years?
- A scenario question – The City of Melbourne has decided to redesign the soundscape to the city. They've called you in as a consultant and have started by asking you what could be improved. What would you tell them?
- Do you notice a quality to the way different people listen?
- Can you talk about building up a spatial memory of a place? How do you return to a space you've visited in the past?
- Do you find that some sounds are more invasive, that any sounds really dominate others?
- Do you make special trips to hear sounds?
- What are your experiences being on a busy street or in the City where there are lots of sounds coming from everywhere? How do you navigate such spaces?

The final project included twelve formal interviews with individuals and groups ranging in age from six years old to seventy; and many other informal conversations during visits to organisations for the sight impaired. Most participants were either living in, or visiting Melbourne, and had some association with blind support organisations such as the Royal Institute for the Blind (RVIB), Vision Australia and Guide Dogs Victoria who greatly assisted in facilitating access to the blind community for the Project. Some participants contacted me directly after broadcast interviews I did for the Project on local radio stations for the blind. Nearly all interviews were conducted in participant's homes or at participating organisations. In one instance, I recorded a participant using a small hand-held recorder while we walked through inner city Melbourne. In this interview, the questions act as an auditory-guided tour of the city. Based on this experience, we returned to the City early one Sunday morning to record the sound of the subject’s cane on as many surface textures as possible (see discussion and recording of *Philip conducts the City*). Some of the interview process was undertaken prior to commencing the PhD candidature, however, all analysis leading to site recording, production and exhibition design was conducted in the Level 7, Building 8 studio of the School of Architecture and Design (see Image 21, page 152).

During the interview processes, I began to fashion draft versions of the acoustic moments by printing notes and arranging these as small text blocks side-by-side in a workbook. Compared to the final text descriptions these are rough, quickly produced and intended sketch the conceptual design of the final exhibition. A page with draft moments appears in Image 28. In the bottom left corner is a reference to large and small sounds, which influenced the acoustic moment *Symmetry.* Just to the right of centre, is an early description of the acoustic moment *Impulse-Response.* The other text sketches on this moment were not realised in the final exhibition.



Question

Moment - Melbourne soundscape scenario "The City of Melbourne have decided to redesign the soundscape of the city. To help, they have employed you as a consultant on a briefing committee to offer suggestions on how to improve the soundscape of the city. What would you tell them?

Answer

Gary likes the big sounds, the sounds that fill out into space, like the clock on the GPO. They are a useful landmark with a definite function and role. Diamaru sounds of clock great, but difficult to hear, Not too many reflective surfaces – "wider spaces" better or worse? Having quiet spaces to just sit and listen would be good. The sound of water also, but not like the water wall, this just blocks everything away. Would suggest drips, rhythms, spaced out, not in a block.

Would suggest "cue" sounds, [LH – one could listen the city] that are permanent and subtle e.g. a little kiosk on a train station or on the street has money dropping, people's feet, papers and chip packets. Same for a telephone box, they have muffled voices.

Moment a street work to show these cue sounds.

Moment – a collage of the exhibition - an imaginitive sound walk through a designed space: 6 minutes. Process in Lake Audio System.

a speculative sound scape

LH – perspective, acoustic proportion, of small to large sounds.

Moment Australian blind cricket is played on a concrete pitch, Indian is played on a hardened dirt pitch. The Australian ball is made from black woven plastic with a metal bell inside. The Indian is made from plastic and has beeds inside. It is not as loud as the Australian ball.
Place a stereo mic at one of a pitch, bowl an Australian and Indian ball past the mics.

Moment on train platforms, announcements are difficult to understand - if sitting under speaker, then its OK.

Moment impulse in 3 rooms, name surface of floor, walls, ceiling and size of room (big, small, medium) or kitchen, concert hall, library. Put a click at start of moment, do this three times. Put answer near exit door. Example Call this moment 34a) b) and c).

Moment Braille music class dictation "negotation of music space" have a braille musical example and a sighted musical example.

Moment David likes listening to shortwave radio, especially control towers

Image 28: SoundSites *several early acoustic moments*

This image shows a scan from the SoundSites *workbook. These short texts were generated from comments or question responses made by blind interviewees. By keeping some texts brief, I was also starting to test solutions for the text panels, which would also be succinct in form.*

Secondary research

Prior to site recording and production, I familiarised myself with visually impaired culture through activities such as observation of mobility training for unsighted teenagers. This is a short walk taken through streets where students may have to verbally indicate features of the environment they hear. During the walk, a sighted guide might point out physical features that could be used for echolocation. This skill can also be used on public transport where large physical features such as overhead bridges, or cuttings produce a qualitative change in the immediate soundscape. This experience was translated into the acoustic-moment *Bridges and Trains.* At some point, the sighted guide will stop the group, and ask them to detail how they would retrace their steps to return to the start location. The teachers were firm with those who couldn't accurately describe their return route, or those who hadn't mentally recorded a spatial map or noted enough features of the auditory terrain as markers to find their way back.[94]

As a sighted listener, the most useful technique I found for observing the soundscape was to walk with eyes tilted downward, not blindfolded. I experimented with a full 'blind walk' during the process of producing *SoundSites*, with my guide on that occasion being Michael Piggot from the Royal Victorian Institute for the Blind (RVIB). However, I found the removal of sight too distracting, and not sufficiently focussing, leading me to conclude that perhaps an extended period of adjustment to temporary blindness might have been more useful for the Project's purposes.

Site visits for recording locations

The portable configuration of the ambisonic recording system is shown in Image 29. The system was powered from a rechargeable dry cell battery with recordings made onto four channels of an eight channel hard-disk recorder. All cables, battery, ambisonic unit, microphone and leads could be stored in the box. Given the effort required in transporting the system to a site even by car, I made a point of visiting potential recording sites ahead of time. During these visits, I would assess the potential of a site by focussing on how its acoustic environment might translate to a recording.

94 This is active seeking as opposed to passive reception. A middle-aged participant also commented that if visiting a new location, he would prefer to find it on his own, as the initial trip will make a better and more easily recallable imprint on his memory than visiting with a sighted guide.

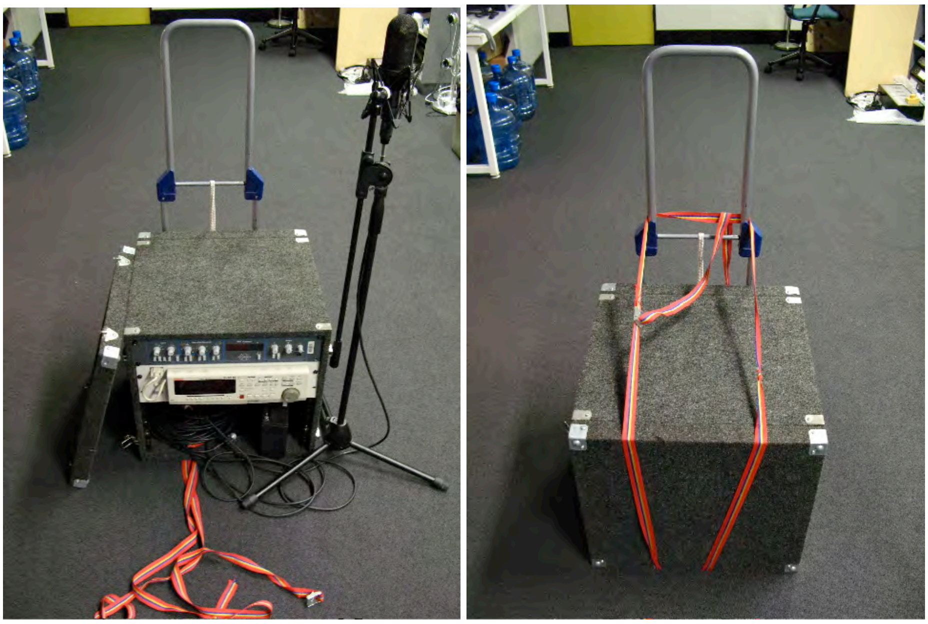


Image 29: SoundSites *ambisonic recording set-up*

The box (left image) contains the top down, the MkV processor for the ambisonic microphone, the Fostex D90 multichannel recorder, and on the bottom, the DiaMec rechargeable battery and cables. The box dimensions are 540 mm (w) x 520 mm (l) x 500 mm (h), and it weighs approximately 10 kgs. The image on the right shows the box closed and secured to a trolley ready for location recording.

In all, approximately 333 minutes (5 hours 33mins) of location and staged recording were made to produce the final 55-minute work. This indicates the amount of material captured for useable exhibition audio. The effort required to record, edit, decode and store a project made in the ambisonic format in 1999 was such that careful planning was necessary to ensure timely project delivery and within available resources. As hard-disk, and other storage is now cheaply available, as are a range of decoders, the Project could be undertaken more efficiently in terms of hardware logisitics.

SoundSites form

The term acoustic-moment has two precedents. The first invokes Karlheinz Stockhausen's notion of moment form as a contained unit of time. The second is the common use of the word 'moment' to indicate a period of time with fixed but indeterminate length, though generally held to be short. With the 'moment' as the main exhibition unit, the task of defining an order, or final collection of moments proved difficult. I wanted to retain the sense of a mosaic, of daily transition between interconnected acoustic environments, but in a subtle, rather than didactic way. Toward the end of the Project, I undertook the following exercise: All titles of possible moments were printed onto small pieces of paper, and positioned on a large table. This allowed a free association between themes, sites, ideas and concepts. Once the final order was arrived at, the notes were replaced into a workbook (see Image 30, on page 190). Although the Exhibition can be traversed in any direction (and moments skipped), I thought most people would travel from beginning to end in the given order.

Although an episodic form is implicit in the idea of twenty-four moments, their fashioning into a coherent whole proved difficult. Prior to this exhibition, most of my practice was based on linear composition and performance of instrumental or electroacoustic music whereas an exhibition unfolds at a time partially determined by the viewer arbitrarily strolling between works. Although many paths through the work are possible, the whole should exhibit a coherent entirety, which required some moments to be excluded late in the process. A note in the bottom right hand corner of the workbook shown in Image 30 shows the three moments ultimately deleted by the end of the production process. They were *Conversation, Interlude Water Ensemble,* and *Wet and Dry,* however, *Interlude Water Ensemble* did appear in the final version of work. The reasons for their exclusion were varied. During the period of production, Melbourne was subject to a severe drought. Consequently, it never rained at a time I could record source material for *Wet and Dry,* which was intended to recall the searing passing of car tyres on a wet road. Logistic and technical issues prevented *Conversation,* being produced. I simply exhausted the time required to locate a suitable café in which to record material that was neither too dense nor presented a wash of incoherent sound. I had identified a particular effect: a blurring of the ambience with occasional distinct words, phrases or sentences appearing inmuch the same way a telescope might pass over a landscape flicking back and forth and attending to smaller details, or absorbing the vista. An even smaller note, also in the bottom right corner reveals another production constraint in 1999. The text notes: "burning time = ca 15 mins:. 4 an hour [next line]:. 12:30-3:30 12 burned." In 1999, it took one hour to burn four CDs on available technology. The Exhibition required fifteen CDs. The significance of this calculation is that the burning was completed at the last available moment, of course.

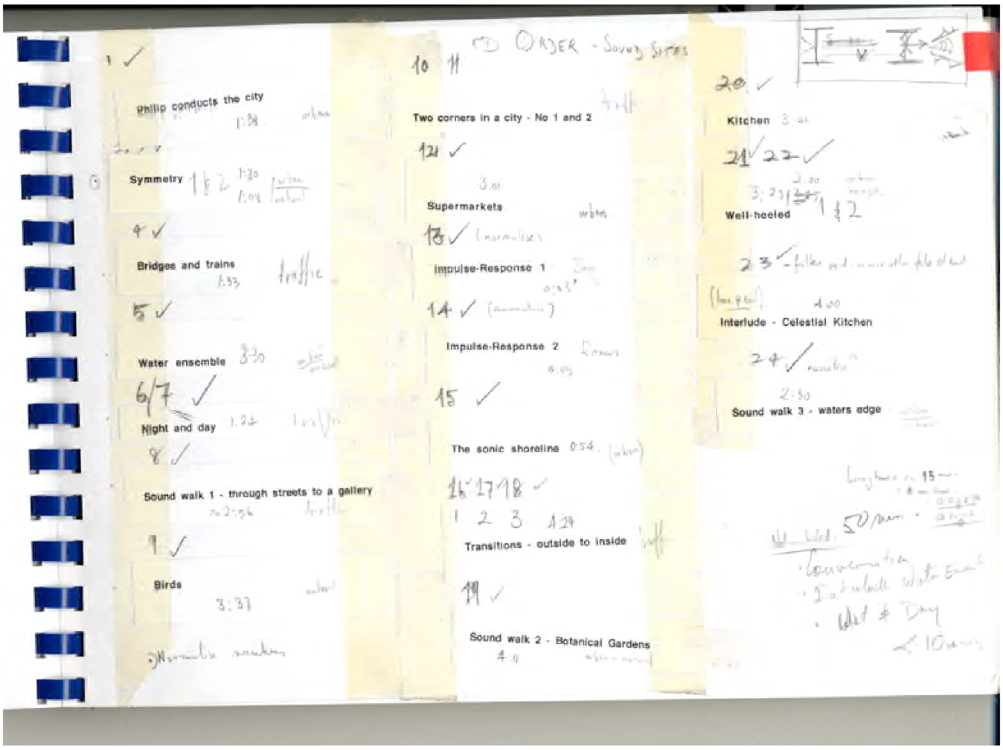


Image 30: SoundSites *workbook final selection of acoustic moments*

This scan from the SoundSites *workbook shows the final ordering of acoustic moments used in the Exhibition. Three moments that were deleted in the final version are listed in the bottom right hand corner of the image. The ticks and time durations written near titles were part of final production checking.*

Studio production

The studio production for *SoundSites* comprised:

- decoding of ambisonic recordings in Lake DSP system and uploading to PC
- uploading of stereo recordings to PC
- editing in *CoolEdit*
- interim storage onto DAT or CD as the PC had very limited internal storage capacity

While studying in Paris between 1995 - 96 I developed the practice of keeping work tapes. I capture 'takes' in the studio while working, and make copies for back-up purposes but also to build material for later use. The tapes are logged in a small book stored with the tapes with the intention of converting these entries to typed tape logs inserted in DAT cover, a practice that has eventuated on occasion.

In order to demonstrate the way an acoustic moment is sometimes a compilation of individually recorded gestures, the following tape log from "RMIT Work Tape 1" is included as source recordings for the two 'Kitchen' moments in *SoundSites.* The tape logs are from 1:37:10 to 2:01:00. For actual recording, the ambisonic microphone was set in a kitchen, while I recorded prepared events for example, the sound of a lid being removed from a pot, a roast cooking, ice falling into a glass, a bottle of wine being opened, a kettle being removed from a stove. Two kitchens were used in the recording although this is difficult to distinguish in the final recordings. The final material was used in *Kitchen* and *Celestial Kitchen.*

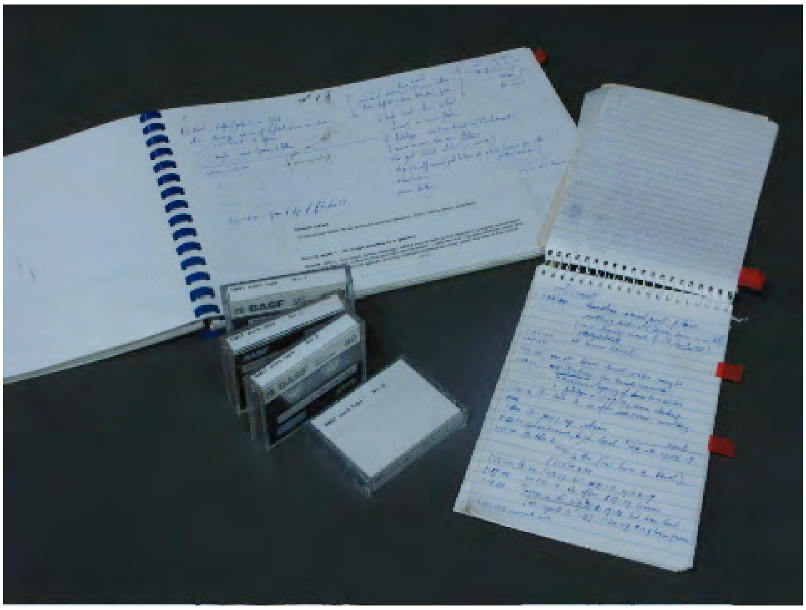


Image 31: SoundSites *production documents*

Tape log (front right) workbook (rear) and work tapes (left) from SoundSites*.*

Making an accessible exhibition space for the unsighted

Access for both sighted and unsighted audiences to the final exhibition was of paramount importance. The main access features for unsighted visitors were the inclusions of Braille text panels, Braille numbering on the walls, spoken track numbers on the CD, and headphones with small tactile indicators on a remote control. The Braille text and number panels were printed on hard plastic (see Image 36 on page 197). Metal was initially considered, but curator Samantha Comte found that the sharp edges on the metal plates and the difficulty of mounting them on a wall meant the plastic sheets of the final version was both a more amenable and cost effective solution. Timing considerations once again meant that the panels had to be confirmed at least ten days before the final exhibition opening to allow time for printing.

The solution for providing navigational assistance around the space for visually impaired gallery visitors also proved to be a simple one. Initially, we considered adapting a rope as navigational aid, but the satisfactory resolution proved to be another lesson in how those without sight navigate space. The exhibition environment of the first show in Melbourne was a compact, shoebox-like space. By giving simple directions and verbal cues, unsighted audiences could easily and safely move around the whole show. Invigilators gave the following instructions accordingly:

> "The room is about ten metres long with a wall at the end and about four metres wide. There are no obstructions along the wall, only six chairs in the middle, if you want to sit. Its okay to touch the wall as a guide, nothing is breakable, and you won't trip on anything. The Braille panels are about chest height, with a small, separate number for that panel on the bottom right corner. Each CD track has a number, so press 'play' or skip until you find the matching number. Here is the CD player. Press this button for play/pause, this is skip forward, and this one, skip back. Volume wheel is here."

Image 32: SoundSites *exhibition space*

The first SoundSites *exhibition at Span Galleries, Melbourne. Ten of the text and Braille panels can be seen around the walls. The panels commenced on the wall at left of image and continued in sequence to the end of the wall on right.*

Image 33: SoundSites *exhibition visitors with headphones*

Image 34: SoundSites *unsighted visitors*

A group of unsighted students and sighted teachers visiting the exhibition in Melbourne.

5.2 *SoundSites*: completed project and exhibition

Final form of exhibition and materials

The completed project contained the following acoustic moments:

1.	Philip conducts the city
2. & 3.	Symmetry
4.	Bridges and trains
5.	Water ensemble
6. & 7.	Night and day
8.	Sound walk 1 - through streets to a gallery
9.	Birds
10. & 11.	Two corners in a city - No 1 and 2
12.	Supermarkets
13.	Impulse-Response 1
14.	Impulse-Response 2
15.	The sonic shoreline
16. 17. & 18.	Transitions - outside to inside
19.	Sound walk 2 - Botanical Gardens
20.	Kitchen
21. & 22.	Well-heeled
23.	Interlude - Celestial Kitchen
24.	Sound walk 3 - waters edge

Sound example 33: SoundSites *Project*

The text from each exhibition panel that accompanied these acoustic moments appears in Appendix 2.

Both *SoundSites* and *CitySounds* (described next), investigate how auditory experience accumulates in the daily navigation of space by listeners. The 24 acoustic moments of *SoundSites* sit within three types of setting or events in Table 22. Most of the settings are city or suburban based. This reflects a possible bias in the group interviewed who all lived in and around Melbourne. However, one of the unsighted teenagers visiting from a country town for mobility training did comment that the vast array of sounds in a city made for a more interesting life than the quiet of the country. For her, even city roads were more interesting than any country sounds. However, I did attempt to balance the number of acoustic moments to types of settings as way of revealing variety to listening contexts. This was particularly directed so asnot to emphasise the sounds of a city, but to show that even within a city, there is subtlety and difference.

The text panels are intentionally brief. The rationale considers the attention span of gallery visitors to stand and read extended descriptions, which I determined would have been an unreasonable proposition. Additionally, the role of the panels was to provide the smallest window, or contextual statement necessary for the 'scene' to be set for a listener. Recalling one of the original motivations for the Project being art shows with didactic panels and audio commentaries, I wanted to maintain the brevity of such panels along with their general graphic layout. To that end the text panels were printed in Helvetica font, no serifs , and measure 280 mm x 280 mm. The Braille panels measure 280 mm x 210 mm. The entire exhibition can be transported in two boxes measuring 770 mm (l) x 340 mm (w) x 225 (d). The CD-players and most of the headphones travel in one box, the text and Braille panels in the other along with other installation materials and documentation.

Soundwalks	**Navigation**	**Domestic & Natural**	**Urban**
Philip conducts the city	Bridges and Trains	Symmetry 1	Symmetry 1
Sound walk 1	Impulse-Response 1 & 2	Water ensemble	Symmetry 2
Sound walk 2	The sonic shoreline	Birds	Night and Day
Sound walk 3		Kitchen	Two corners in a city
		Interlude elestial Kitchen	Supermarkets
			Transitions – outside to inside (1, 2 & 3)
			Well-heeled

Table 22: SoundSites *categories of acoustic moments*

The acoustic moments have been sorted into three types of setting. An acoustic moment is present in more than one setting, where it contains material of two settings.

Image 35: SoundSites *exhibition boxes*

In the lower image, the box on the left contains most of the CD players, the box on the right has the remainder of the CDs, exhibition panels and other items. The exhibition inventory is fixed to the inside of the lid.

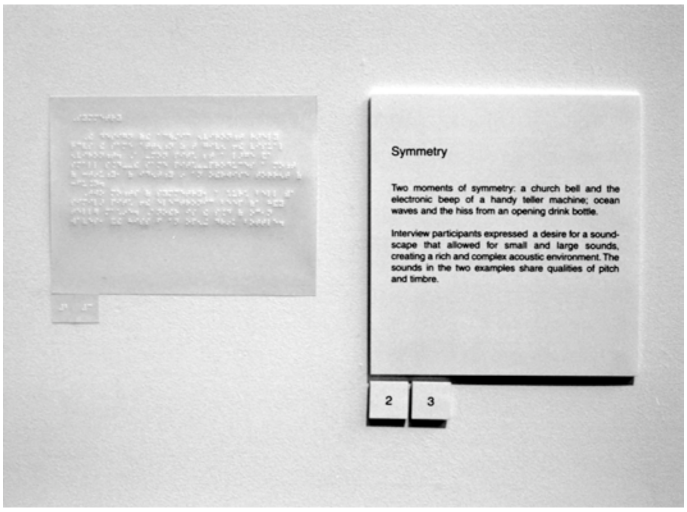


Image 36: SoundSites *Braille and text panel*

The Braille panels were all placed immediately to the left of text panels. Both text and Braille panels for all acoustic moments were the same size through exhibition.

Image 37: SoundSites CD pouches

A CD pouch with CD and headphones. The control is in the foreground, resting on the CD pouch.

Visitation statistics

In planning the first exhibition in Melbourne, I lacked an exact measurement as to longevity of the battery charge in a CD player. To ensure that exhibition visitors were given a CD player sufficiently powered to hear the duration of the exhibition CD content, the following system was implemented. Firstly, each CD player was numbered between one to fifteen. When a CD player was given to a visitor upon entering the exhibition, the time was noted as was the time the player was returned to the exhibition front desk. By vigilantly checking how often each individual player was used and the duration of each use, it was possible for exhibition staff to determine which CD players had been used the most and should be charged on a rotating system. This data was also used to generate the visitation statistics in Table 23 and Table 24.

Visitation categories	**Totals**
Total number of visitors for Exhibition	595
Maximum per day	60
Minimum per day	23
Average per day	37

Table 23: SoundSites *visitation statistics per day for the Melbourne exhibition*

Visitation time	Totals
Maximum duration visit	65 mins
Minimum duration visit	2 mins
Average duration per visit	25 mins

Table 24: SoundSites *visitation durations collected by Invigilators*

Anecdotal comments I collected from visual arts curators and exhibition designers, suggest that the time spent by a viewer with an artwork is often less than 30 seconds. Even a general comparison with the durations in Table 24 leads to some interesting observations for the ability of sound to extend and modulate the gaze, and hold viewer attention. In a sound-based work it is, of course the sound designer who determines the temporal organisation for the work's unfolding. In the case of a visual work, the manner of a work's unfolding is largely in the control of the viewer. They may choose at some point to 'stop' the piece, by walking away. Similarly, a listener in the scenario of a gallery exhibition with headphones also has a control to 'stop' the work and walk away, however, these figures suggest that most visitors chose to listen to just under half of the full work (see average duration per visit in Table 24).

5.3 CitySounds: description of process

The city and games engines as soundscape laboratory

Where *SoundSites* was a mode of working on a singular artistic endeavour, *CitySounds* very much exemplifies an expanded mode of practice. By the time of *CitySounds* realisation, I had been appointed to a full-time position in the SIAL Sound Studios. My role was to manage the development of the Studios from the oversight of a successful equipment grant, through construction and start-up phases, to a fully functioning teaching and research unit in the School of Architecture and Design. I had commenced the PhD in architecture to seek a re-direction of my practice through a long held interest in the spatial qualities of music and sound design, and perhaps too, as a way of moving on from the pre-PhD project to establishing an independent electroacoustic studio in Melbourne. Yet by 2003, I was substantially responsible for establishing a new studio, albeit one based in an institution but with the potential to realise the original multi-themed agenda I had previously envisioned for the inchoate independent studio.

In the intervening four years between *SoundSites* and *CitySounds,* my interest remained in projects that would address tangible community issues. As mentioned previously, the role I then occupied in the SIAL Sound Studios meant my thinking by necessity, had to shift from the speculative potential of a studio, to actual operational issues. I was now more convinced that an electroacoustic studio could be a centre where cultural, design, research and educative roles into the auditory experience of the city could be pursued within the immediate environs of the city. That is, the notion of the city as soundscape laboratory. In the teaching activities of the new sound studios, I had been involved in two design studios based in games engines[95], and through which I developed ideas and approaches to using games engines as soundscape teaching environments. In *Resounding City: acoustic ecology and games technology* (Harvey & Maloney 2004), Jules Moloney and I expanded on the notion that the audio spatialisation capabilities of game engines were ideal for maintaining some attributes of sound-listener relationships in physical space. To that end, game engines could be considered a useful teaching tool as they maintained certain contextual factors for the listener.

The ephemeral quality of sound and the electroacoustic methods for its representation in virtual environments predisposes aural experience as an ideal subject of enquiry into human action and reaction in the actual world. Yet, within ocular-centric Western design culture, aural experience is generally held as too elusive for design intervention. The challenge then, is to discover methods that not only raise aural awareness amongst designers, industry, communities and government, but also to make tools for designers with which they may consciously attend to the local soundscape of Melbourne. This was an objective of the *CitySounds* project.

Qualitative information, noise complaints and acoustic measurement

Between 2002 and 2006, the City of Melbourne responded to the changes in the acoustic environment of the CBD[96] by means ofseveral of initiatives. These included a noise management plan, establishment of a noise management team, lobbying of industry and other government bodies, codes of practice for noise caused by waste removal, international benchmarking, and fact sheets and surveys.[97] The Noise Unit was also formed in recognition of the fact that any responses to noise issues would require working across municipal departments responsible for

95 See <http://www.sial.rmit.edu.au/Projects/Memory_Games.php>, and <http://www.sial.rmit.edu.au/Projects/Future_Sound.php.>, viewed October 5, 2006.
96 The Melbourne CBD is approximately 2 km^{2}. The City of Melbourne is around 36 km^{2}. The CBD appears in the map on for Image 42.
97 The full list and overview is available from <http://www.melbourne.vic.gov.au/info.cfm?top=46&pg=1648>, viewed December 13, 2006.

environment and health, collection and waste services, urban planning, strategic and economic planning and street activities. Although the Council has been successful with a programme to encourage outer suburban residents to relocate to the CBD, this diversification of innercity space use has caused a range of sound and noise-related issues. In Council's *CityHealth 2002, City of Melbourne's Municipal Public Health Plan*, the status of noise complaints against other environmental health issues is such that: "Noise complaints far outweigh other environmental health issues such as waste disposal, odour and refuse complaints, pest control and illegal discharges" (*CityHealth*, Page 9).

Like many inner city councils, the primary source of information available to the City of Melbourne about sound issues comes from ongoing complaint procedures and intermittent noise measurements by acoustic consultants. It was not known if complaints represented the attitudes of the general community, or if particular types of complainants skewed Council's perception that a majority of people were significantly disturbed by noise. A broader spectrum of knowledge than just negative perceptions was required if Council was to proactively address sound-related issues in the CBD, using any of the five initiative types listed below. In early negotiations for the project, Council officers expressed reservations about further objective measurement studies by acousticians. Their thought was that these measurements would confirm what they already knew to be the case, that parts of the City were negatively affected by noise. Council was interested in an alternative approach to gathering information that might reveal alternative methods or strategies for dealing with sound-based issues in the City.

The extensive variety of sounds in cities and their impact on listeners is rarely investigated by government agencies. Most survey and measurement projects are directed toward "specific sources of annoyance, such as traffic and aircraft, and…[are]…not concern[ed]…with broader questions of how sound functions in the community" (Truax 2001, p. 88). Truax notes that an exception to this was a study carried out by the Institute of Sound and Vibration Research of the University of Southampton (Hawkins 1980). The differentiating factors of this study are its focus on low-noise rural environments, and the questionnaire style where respondents could express both positive and negative responses to sounds (Truax 1980, pp. 88-90). The *CitySounds* survey focussed on the wider acoustic environment to broaden Council's spectrum of knowledge about listener awareness and attitudes to sounds in the Central Business District (CBD) of Melbourne, and to determine if noise complaints were representative of wider community attitudes to the acoustic environment.

Aims, purpose and intended role of the Survey

The aim of the *CitySounds* survey was to investigate community attitudes toward and awareness of a range of sounds in a variety of contexts in the Central Business District (CBD) of Melbourne. The purpose of the survey was to provide Council with a broad scope of information to help with the development and implementation of noise management initiatives using:

- planning and design guidelines,
- information campaigns for residents and general community,
- better handling of complaints,
- development of information for current and prospective residents on personal strategies for managing noise issues,
- information campaigns for targeted industries for example, entertainment, construction, retail,
- design and management interventions affecting acoustic experience of the city,
- any other innovations identified from survey results.

The project was intended to, and did deliver insights into the attitudes and awareness of respondents of Melbourne's soundscape to the local government client. It was also to be generative of a cultural dialogue about the local soundscape. The project had a secondary role to 'feed-forward' information from Council to residents as an awareness-raising and education campaign in relation to listening, sound and urban environments.

Precedents & development of the games environment for soundscape research

From the late 1990s, there has been a steady, then rapid increase in the use of computer-based gaming software adapted for architectural education. In RMIT University's semester 2, 2002, I coordinated the *MemoryGames* design studio, and taught the sound components for this subject. The studio was co-taught with Professor Mark Burry, Gregory More and Jules Moloney. A second games-based studio, *The Future Sound of Cities* followed in 2003. In papers reflecting on the process and outcomes of these teaching studios co-authored by the group we observed:

> The StringCVE[98] [Collaborative Virtual Environment] becomes a soundscape laboratory, creating an immersive experiential learning context for students. Instead of presenting definitions, descriptions and linear recordings to explain sound concepts, students design their own virtual acoustic environments to test and explore their understanding of concepts (Moore et al. 2003, p. 130).

The combination of teaching interactive sound to architecture students, software development for *Ecstasis* and the establishment of the SIAL Sound Studios proved a fertile ground for the emerging idea of using a games engine for soundscape studies. During the two

98 This was the virtual environment used for the design studio using the Torque games engine.

design studios, I was engaged with around 30 student projects and developed teaching concepts and lectures based on soundscape studies and interactive sound design. This developmental period is summarised in the final sections of the *ResoundingCities* paper, written over the summer of 2003 - 04:

> We are seeking to enact long-term change by making young designers about to enter professional practice aware of the aesthetic, social, cultural, health and environmental aspects of the soundscape. This endeavour is substantially based on concepts and methods from acoustic ecology and by adapting desk-top technologies from the games industry so that students may undertake experiential design learning via the simulation of built environments, and in particular the soundscapes of those environments. We are also pursuing extensions of this approach to researching community awareness and attitudes to local soundscapes (Harvey and Moloney 2004, p. 832).

CitySounds was a community soundscape survey that culminated in a report containing a series of considerations to Council.[99] Perhaps more accurately, the Project should be described as a consultative tool. I cannot claim that the idea of embedding a survey in a games engine was fully formed by a particular date, nor the result of a systematic process of consistent investigations as might be conducted in a scientific laboratory. It was a proposition emerging from two interrelated streams of my practice - soundscape pedagogy in a school of design, and sound design and composition for multi-channel sound systems. I prefer the term *embedded survey* to describe the technique of a survey spatially located in a games engine. The embedded survey technique could be adapted for a range of research and communicational projects, particularly where contextual or environmental factors are required as part of the testing environment. That is, the reductionist model of a lab is not suitable to the situation under investigation. Other uses might be for master-planning community consultation of new urban developments, scenario testing of circulation system in buildings, or situations where combined temporal and spatial dimensions of a design must be studied in parallel.

CitySounds – Community noise survey or soundscape research

Community noise surveys are traditionally undertaken to study subjective responses to major sources of noise from, for example, airports or highways. These surveys tend to be text-based and rely on participants' ability to recall past aural experience and remembered responses. One difficulty with this memory-reliant approach can be demonstrated by the following exercise: notice the difficulty you, or others might have, trying to precisely recall the last sound you heard last night, and the first sound you heard this morning.

The reductionist model of testing respondents in a lab was avoided in *CitySouds* in favour of users responding to the survey in their daily environment. This was appropriate as

99 The findings were called 'considerations', and not 'recommendations' as Council officers felt the former would imply Councillors had to take definitive action on the Report results, whereas considerations could be pondered.

the Project was investigating subjective, or qualitative responses to sounds in a range of contexts.

The *CitySounds* or *embedded survey methodology* is substantially built on the listener-centred approach of acoustic ecology, which is the study of the relationship between individuals and communities and their acoustic environment (or soundscape). In his discussion of survey methodologies, Barry Truax criticises those approaches that measure reactions to specific sources of annoyance, and are not "concerned with broader questions of how sound functions in the community" (Truax 2001, p. 88). The methodology developed for *CitySounds*, was designed to investigate how some of these functions operate by linking settings, sounds and listeners. Another way that the noise annoyance approach differs from *CitySounds* is by considering Truax's two models of sound environments presented in Chapter 1 – the communication model and the energy model. *CitySounds* falls into the first, while noise surveys fall into the second. Community noise surveys are traditionally used to study subjective responses to discrete sources, for example, train, aircraft or traffic noise. They are comparative tools often used in parallel with objective technological measurement, and sometimes used to track changes in community awareness of noise sources.

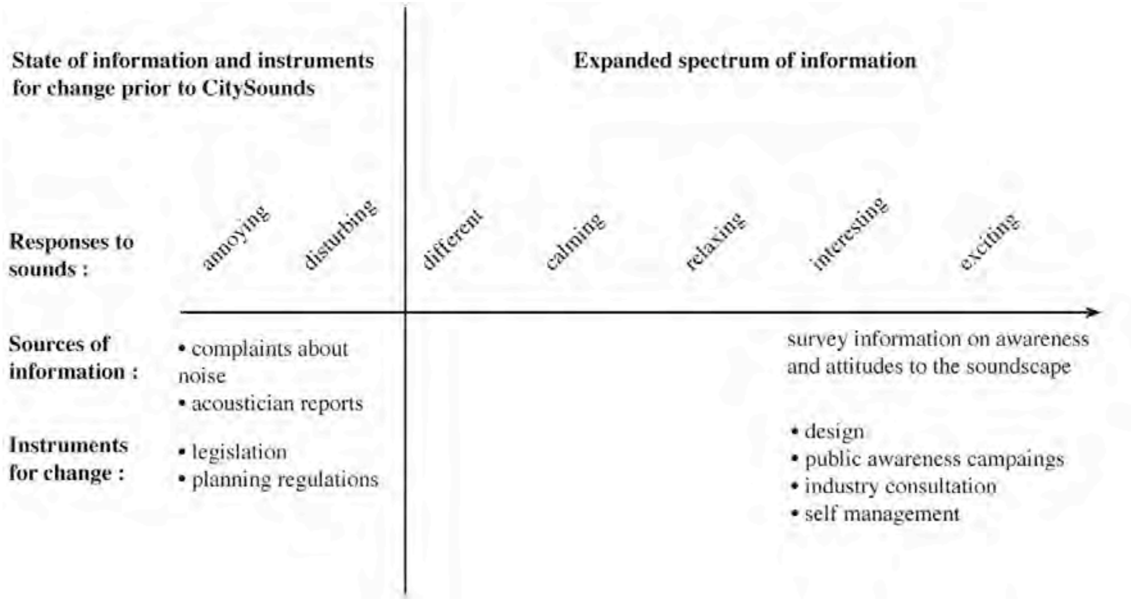


Figure 24: CitySounds *spectrum of information*

This schematic was developed for briefings to Council and other groups describing the aim of the survey to extend the spectrum of information available for soundscape design and management. The left of the schematic describes the known responses to sounds, sources of information and instruments for change at the start of the CitySounds survey. The right hand side was the intended state at the end of the survey.

Brief outline of project stages

The project stages for *CitySounds* were not clearly demarcated, but considerably overlapped in production caused by two main factors. The first was the need to develop the model and survey in parallel with consultation with the Council. Sometimes, a set of survey questions would drive the need to create a new spatial typology in the model. In other instances, a spatial intervention, for example, site-of-respite, would require development of a new set of survey questions. The second factor was the nature of the milestone process. Following a milestone and agreed list of changes, the process to generate sections of the model, soundscape design or survey design would be repeated to add to, or modify a section of the project. The stages of the project are outlined in Table 25, although this is not a temporal ordering.

Stage	Process or activity
1	Consultation, assessment and determination of site types.
	Consultation with City of Melbourne staff to establish criteria for virtual precinct creation and soundscape design.
	Listing of actual sites for modelling and audio recording.
	Initial assessment of sites at different times of day by project team.
	Initial sound recording and digital image capture as the basis for indicative site modelling.
2	Sound, image and data capture.
	Digital audio recording.
	Digital image capture.
	Texture capture and library creation.
3	Virtual environment construction.
	Production of 3D model of site, including selected interiors.
	Soundscape production in parallel with questionnaire development.
	Optimisation for on-line delivery and testing.
4	Research questionnaire.
	Research previous local and international community noise surveys.
	Development of community response questionnaire.
	Development of on-line delivery system for results.
5	Survey Active.
	Live release and maintenance for seven months.
6	Survey report

Table 25: CitySounds *project stages*

This table shows the main stages of the CitySounds *project. The table is not strictly ordered in time, as stages overlapped or were undertaken in parallel.*

5.4 *CitySounds* completed project

The *CitySounds* survey was launched on the 12th of August 2004 and made available to the public approximately one week later. The 3D model was released online, made available on CDs, and could be accessed at city-based libraries. The survey was 'live' for seven months, closing on the 31st of March 2005. Analysis and writing of the report were completed in the second half of 2005, and the report officially released in early 2006. Approximately six hundred people responded to the survey generating 3,949 reportable results.

Description of project and components

CitySounds comprises three integrated components or assets: a 3D virtual model of an inner city precinct, an interactive soundscape and an online survey. Participants visited nine sites, or general space types, and their associated soundscapes while completing the questions in the model. In addition to general questions about sound, respondents were asked for their opinions of sounds heard at seven indicative city locations inside the virtual model:

- a café
- two sites-of-respite
- an apartment
- spaces affected by air-conditioning
- nightclubs
- construction sites
- general street ambience

The following diagram shows the path and sites visited in the guided tour mode of the project.

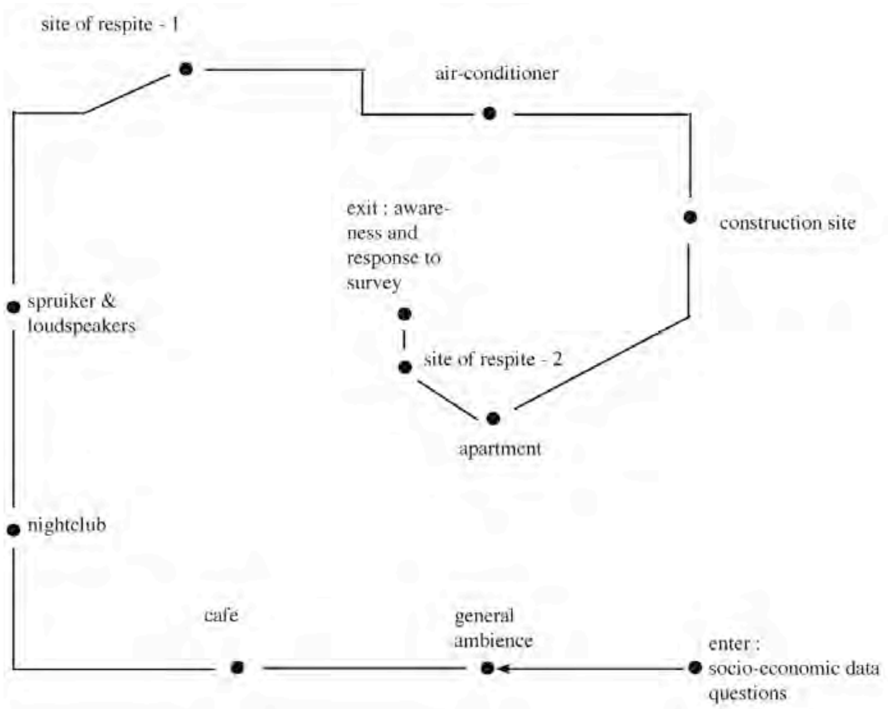


Figure 25: CitySounds *sites visited in tour mode of* CitySounds *project*

Each of the 11 sites in this schematic had one panel with one or more questions. The exit site pictured in the middle of the above diagram would appear when the user pressed the escape key either on completing the guided tour or finishing early.

Site	Audio	Visual	Example questions
Café	Coffee machine, general ambience, voices	Small café	In relation to the noise levels in cafes over the last 3-5 years, do you think they have generally become… (5 options provided)
			If you think they have become noisier, what do you think is the main reason? (please tick only one response) (6 options provided and 'Users own words accepted')
Site of respite	Electroacoustic soundscape in No.1 and water feature in No. 2	Sculptural object in No. 1 and small water feature in No.2, both static images	If a site-of-respite was around 5 minutes walk from your office or home, would you use it?
			Would you manage your daily routine to spend time in such a place? (You may select more than one).
An apartment	Source sounds processed differently for each space: bar patrons, garbage delivery, bottles smashing, band sounds	Rooms in apartment	Would reducing the level of sound entering your home improve the quality of your life?
			What would you expect to pay for sound-proofing a room to reduce noise levels entering that room?

Table 26: CitySounds *summary of material and questions for three sites*

For each site, a unique series of sounds was recorded and a visual design developed to support the questions of that section.

The final project was approximately one and one half city blocks in size, and contained around fiftysound files. The project team appears in the following table and included sound designers, a social scientist, computer programmer and 3D modellers.

Role	Person
Project Direction, Management and Lead Sound Design	Lawrence Harvey
Lead 3D and Visual Design	Foo Chi Sung
Lead Programming	Yamin Tengono
Survey Design	Lawrence Harvey, Kim Leong (Social Science & Planning) Russell Webster (Noise Unit, City of Melbourne)
Acoustic Consultant	Peter Dale Applied Acoustics Group
Additional Sound Design	Jeffrey Hannam, Jerome Frumar, Boo Chapple, Yamin Tengono
Additional Visual Design	Dominik Holzer, Richard Le
Additional Programming	Budhi Prasetya
User Interface Design	Yamin Tengono, Foo Chi Sung

Table 27: CitySounds *team*

Unless otherwise indicated, all members were from the Spatial Information Architecture Laboratories (SIAL), RMIT University

Maintaining contextual features: soundscape and visual design

The aural, visual and spatial designs of the virtual model were built on contextual features consistent with Melbourne that were readily identifiable to the target participants. These elements work in concert to construct an indicative auditory experience of an urban environment that a survey participant might encounter in one day. Motion through the model is at walking pace. While simultaneous visual and aural events are experienced, the participant utilises their real-time encounters with virtual places to recall past experience of actual places. Council was sensitive to any individual businesses or precincts being recognisable. Their reasons for this were that members of the public might identify a modelled location with a noisy area and avoid it, with the possibility of detrimental outcomes to businesses or property developers, or landlords in that precinct. Similarly, if businesses were represented too realistically, then a similar detrimental effect might occur should people avoid cafés, restaurants or other commercial outlets suggested as too noisy. While the model had to exhibit many of the aural, visual and spatial elements of a small Melbourne precinct, it was not to be identifiable or construed as an actual location.

Soundscape design

All sounds in the *CitySounds* virtual model were recorded at specific sites around the CBD. They were selected in close consultation with the City of Melbourne to provide a convincing soundscape. For example, sounds associated with Melbourne's trams are readily identifiable by locals, but other sounds featured included busy cafés, general street ambience, air-conditioners, a spruiker[100], and staged events such as patron noise and those for the two sites-of-respite. As an essential aspect of *CitySounds* is its soundscape, all sounds were recorded and kept at CD audio quality (44.1 khz sample rate, 16 bit sampling), and carefully designed to minimise looping artefacts and similar fatiguing effects to do with repetition.

Visual design

All visual textures were collected from Melbourne's CBD buildings. Typical building envelopes and streetscapes of Melbourne such as alleys and laneways, and a mix of 19th and 20th Century shop fronts were maintained, while the bluestone pavement used in Melbourne's laneways was used as feature in the model. Businesses were re-branded with SIAL staff and affiliated projects to give the cityscape some named content. It was a frequent occurrence that people viewing the survey would ask the location of the site, suggesting the sound and visual components successfully conveyed a precinct characteristic of Melbourne. Earlier versions of the model were more populated with people, cars, street furniture and fixtures. For performance optimisation purposes, the model had to be substantially edited at the final stages of production. That is, it was running too slowly and not sufficiently smooth for the project to be convincing.

Survey design: the embedded question panels, online communication and modular form

The survey questions appear as 'markers' inside the model represented by small brightly coloured pyramids. The survey and model could be used in one of two modes. For experienced users of 3D environments, it was possible for them to independently explore the model, as one might access any other navigable 3D environment. For less experienced users, a guided tour was provided. This involved travelling a preset path through the model, stopping at each of the survey markers in a predetermined sequence.

100 A spruiker is a person that stands at the front of a shop with some form of amplification calling out phrases about bargains for the business. Sometimes the spruiker is replaced by a pre-recorded spruiker.

Image 38: CitySounds *survey marker point*

When a CitySounds *respondent intersected with a marker, a survey window appeared. At these points, the sounds, and spatial location related to the survey questions appeared in the window.*

On collision with a marker point, a survey window appears to the user. The final project contained eleven question panels with each individual panel posing between one and fourteen questions. As the survey windows are objects embedded in the physical environment, making substantial changes to the structure of the questions required a window resizing and repositioning inside the model. Although the survey, soundscape and visual design progressed in an iterative fashion, the constraining need to redesign windows occurredseveral times toward the end of the Project. This proved particularly difficult with the imminent approach of the completion deadline. Respondents, whilst in the model entered all answers. After completing a survey window, a respondent selected the 'save' button at the bottom of the window. This would save the results to the local computer (see Image 39). At the conclusion of the survey, or whenever respondents chose to finish by pressing ‘escape’, an exit window appeared containing a ‘send’ button to forward their results to one of three servers commissioned for the project at RMIT University. More than one server was used for risk management purposes. If one server was down, the software on the users’ computer could select from another two. Ideally, one server should be situated off-site from the others to further reduce risk, however, for management and hardware security purposes, this was not possible during the Project.

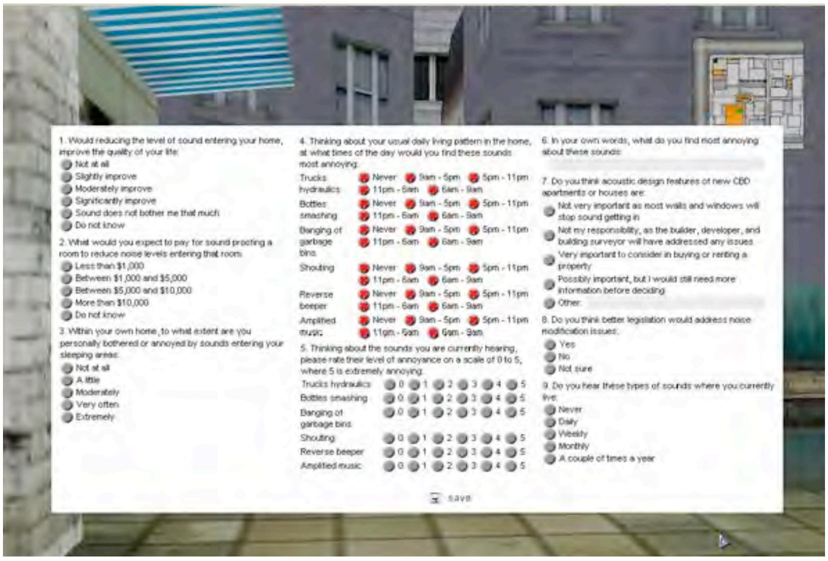


Image 39: CitySounds *survey question window*

This panel of questions appeared on screen when the user intersected with marker. The 'save' button appears at bottom of window.

The modular-survey was developed in close consultation with Council over a three-month period with approximately six major revisions completed in this time. The modular structure alleviated the potential problem of participants not completing the whole survey. The navigation mode described above anticipates this possible outcome should a user not find, or collide with all survey markers. Also, for reporting purposes the modular design meant that sections of the Report could easily be isolated and distributed to relevant Council departments, dispensing with the need to supply the whole survey. Staff of the Noise Unit did so after the Project's completion. The final report contained eleven sections listed in Table 28 and referred to alphabetically as Sections A - K.[101]

101 Summaries and key sections of the Report are available from <http://sound.sial.rmit.edu.au/Projects.php>, viewed October 6, 2006.

Section	Title
A	Results for opening socio-economic and demographic questions
B	Results for General Questions on sound
C	Air-conditioners
D	Apartments
E	Cafes
F	Sites-of-Respite-1
G	Sites-of-Respite-2
H	Construction sites
I	Nightclubs
J	Loudspeakers and spruikers
K	Exit questions about survey

Table 28: CitySounds *sections of report*

To ensure comprehensiveness, the socio-economic data entered by each participant was tagged with the answers to each individual question allowing reporting on a site-by-site, or question-by-question basis. On advice from the Project's Social Scientist, and in agreement with Council, the survey's sixty-eight questions took approximately twenty minutes to complete. The questions included multiple choice, simple 'yes-no' answers and opportunities to provide responses in the words of the survey participant.

During development of the survey, we consciously avoided use of the term 'noise', preferring 'sound' as a way of encompassing the broad palette of inner city sounds and listening contexts. For the listener/respondent, we were interested in how the virtual experience would lead them to consider listening-sound-environment by moving through the model/city and acknowledging that different spaces and places demand different levels of aural awareness and attention. Furthermore, the Council had to realise that sound experiences are diverse and there was no single solution to solving noise problems.

The eleven sections of the modular design survey design included an opening segment for socio-economic and demographic questions (Section A); one for questions on general urban sound (Section B), eight related to specific urban sites (Sections C - J), and one for the exit questions (Section *K*). Sections C - J mirror an indicative daily journey of a listener through a range of urban acoustic environments. The modular design of *CitySounds* was intended to enable:

- the section on cafés to be used for industry consultation and initiatives to promote better acoustic design for cafés
- the section on apartments to inform awareness campaigns on the benefits of specific acoustic isolation, or internal wall treatments
- the sections on 'sites-of-respite', to assist in determining how often respondents would access such a site, and where these might be located in the city

- communication and management strategies tailored to the needs of generational groups in different contexts
- a lesser impact should individuals not complete the entire survey.[102]

Following delivery of the survey and a series of considerations to Council[103], (see *Appendix 1: Original considerations from CitySounds report),* sections of the Report were distributed across Council and were later incorporated into a draft urban design strategy from Council discussed below.

CitySounds conforms most closely to a research project that might be encountered in the social sciences. In this project, I stepped outside my previous discipline boundaries becoming very much Truax's artist-activist. However, this process of drawing conclusions from data about people's auditory experience, or the interpretive part of the Project, I believe is very similar to the process in *SoundSites* – responding to reported experience, translating and interpreting for a specific brief.

Evaluation of three design elements in games engines for soundscape research

Temporal duration

Motion through a games engine is a definable parameter entitled the 'motion model'. For First-Person Shooter (FPS) genre of game, it is likely to include speeds and motions associated with running, flying, driving. The next attribute affecting duration in a games engine is the size of the model. If it is small, and the motion available to the avatar is fast, then the model will be experienced as if stuck on fast - forward. The effect on sounds is likely that they will 'whoosh' by, similar to speeding past a static sound source in a car. All one hears is a 'blur' of sound. During negotiations with *CitySounds*, we had to develop a mechanism for costing the Project. This was done on a 'per-city-block' basis. The Project quickly shrunk in size as we realised that it only required one and one half city blocks for a twenty minute experience, allowing for time to stop and answer survey questions.

The other aspect of duration in an experience controlled by a user walking around is the 'pause'. The user may stop, wait, slow down and speed up, usually within tightly defined limits. But once the avatar ceases to move, looping of sounds becomes an issue as the repetition may quickly become annoying to a listener. Ideally, it would have been desirable in *CitySounds* to embed a short sequence of code to check if the avatar had stopped, for example, while the user answers questions; and to place random pauses in the sounds at that point. Due to project deadlines and other task requirements, it was not feasible to implement such functionality. The solution was to input small silence gaps at the end of sounds, so sounds would not continuously loop, or to use two versions of the same sound in the same location, with different end silence sections.

102 As the socio-economic and demographic data collected were 'tagged' to the answers of each module for each respondent, filters could later be applied during analysis of data to report on sub-sections of the whole survey.
103 Toward the end of project reporting, Council offices requested that recommendations be changed to considerations, thus removing onus on Councillors to adopt or to reject specific items from the Report.

Linear and non-linear temporal design

The difference between linear and non-linear soundscapes is exemplified when considering the way temporal organisation is created. In a linear format, the sound designer predetermines the temporal organisation of the material. In a non-linear environment, the resulting soundscape is organised from the motion of the listener through the environment. As a listener is free to move through the environment, the sound designer creating a 3D soundscape must be aware of the potential way sounds will interact amongst themselves and be perceived by the listener. As the 3D environment is constructed from visual and geometrical elements, the sounds are embedded in context-forming materials, not the disembodied format of linear sound recordings. In general, sound designers for film, theatre, television and radio still work in linear formats; the exception being those working in sound installation VR applications and games development. In a non-linear environment, relationships between individual sounds can be explored over the need to create compositional relationships for the listener. In this respect, the experience of navigating a soundscape in a games environment is much closer to the listening experience of being in an actual environment.

Spatiality

By embedding carefully edited recordings of simulated urban environments within interactive design projects based in games engines, sound is used in both communicational and representational modes. The researcher can investigate relationships created between sound, visual form, occupation and usage – even though sound used in this way is evocative rather than acoustically realistic. Realism here refers to the modelling of complex environmental acoustic parameters such as real-time reverberation through convolution. However, this 'sound-sketch'[104] in a games engine maintains useful acoustic phenomena for a listener in physical space such as precedence effects, localisation and distance cues, as well as a programmatic relationship between sound and place.

As a research and communicational resource, games engines are useful in developing the aural awareness of communities whose relationship to space might be predominantly visual in nature. For example, the following environmental sound interactions (ambience, masking, density, precedence effect) will occur when a virtual environment is populated with sound. The definitions in Table 29 are applicable to interactions of sounds in actual or virtual acoustic environments.

104 Jules Moloney first used this term in co-authored papers. See Harvey and Moloney 2004.

Environmental sound interactions	Description
Ambience	The background sound of an environment in relation to which all foreground sounds are heard, such as the 'silence' of an empty room, conversation in a restaurant, or the stillness of a forest. Ambience is actually comprised of many small sounds, near and far, which are generally heard as a composite, not individually.
Masking	The effect one sound has on another by making it harder, or even impossible to hear.
Precedence effect	The psychoacoustic phenomenon whereby an acoustic signal arriving first at the ears suppresses the ability to hear any other signals, including echoes and reverberation that arrive up to approximately 40 ms after the initial signal, provided that the delayed signals are not significantly louder than the initial signal.
Density	The number of sounding events in a given time frame.

Table 29: Acoustic environment effects and definitions

All definitions except that for 'Density' are from the Handbook for Acoustic Ecology *(Truax 1999).*

In the *Handbook for Acoustic Ecology*, linear audio recordings accompany these concepts. By teaching these concepts in a Collaborative Virtual Environment (CVE), students are not required to make a translation between linear (audio-recording) and non-linear formats that aremostly representational as opposed to experiential.

5.5 *SoundSites* and auditory spatial experience in diverse milieux

> *The City of Melbourne has decided to undertake a soundscape design project in the CBD. They have called you in as a consultant. What would you suggest they change?*
> *(Question from* SoundSites *interviews)*

Introduction

In hindsight, this is a prescient question from the *SoundSites* interviews to provoke respondents into broadly considering the diverse auditory conditions in which they negotiated physical space. It was a question I put to the unsighted participants in 1999, six years before *CitySounds*, but one that resonates with the intention of the later project to uncover the materials of auditory spatial experience.

From our earliest years, discovering the link between sounds and their source helps us to explore the aural aspects of our environment, while the uncoupling of sounds from their source is the basis of a large majority of electroacoustic concert and installation works. Source recognition is often a problem for sighted listeners who tend to favour visual verification of a sound's location, proximity and type, while unsighted listeners must rely mainly on their aural experience and possibly, on tactile, or olfactory senses. Sighted listeners tend to experience disorientation if they are unable to identify the source of a sound. The term 'source' is used here both as a physical location in space and as a 'thing'. Revealed in the interview transcriptions of *SoundSites*, are the cues that interviewees use to build a mental representation of the spatial conditions of their environment.

Language and translation between words to acoustic moments

Although each interview commenced with a basic set of questions, it usually became necessary to diverge from these due to the diverse experiences of the participants, the ability of individuals - and the availability of a language, to describe aural experience. Unsighted people live in a culture that relies almost exclusively on sighted verification of things, events and ideas. Even those people blind since birth, or from early childhood struggle to describe their uniquely aural experience of the world. Interviewees referred to loud deep sounds resonating over some distance as 'large', while softer sounds were referred to as 'small'. Blesser notes that auditory disciplines borrow from other sensory lexicons, and that while a "visual experience is described in terms of the observed properties of the objects, … an auditory experience is described by the object that gave rise to the sound … not by the properties of the sound" (Blesser 2001, p. 885). He gives the example of a bell ring, which is described by reference to the bell, not to metallic clangourous in-harmonic spectra.

However, several interviewees were able to construct very clear descriptions of how auditory spatial conditions had changed in Melbourne. Several older interviewees described the ways individual sound objects had altered perceived acoustic space, in particular, the ways that vehicle and road construction techniques had combined to change the sound from cars since the 1970s. Other differences in acoustic spaces included the ways that wealthy suburbs sounded different from less affluent domains; the subtle changes in ambient sound from a building offset providing navigational cues through the city, or the effect of modern shop-front design in changing the qualities of the *sonic shoreline* in contemporary streets. Whilst none of the interviewees were aware of soundscape terminology or formal environmental listening strategies, I observed how unsighted teenagers undertaking mobility training did gain some training in environmental listening. At the time of *SoundSites*, there were no formal listening training or aural-specific descriptors in use at the Project's host organisations.

Throughout the interview process, I was seeking to find translatable auditory experience. This meant finding an experience, comment or observation that could lead to a site, or determine a staged recording process that would communicate an aspect of 'blind experience' to a sighted audience. To demonstrate the way this was done, several examples of links between comments or observations and their final acoustic-moment are discussed next. In some instances, comments from the participants were suggestive of a recording site, or staged event that was a relatively straightforward exercise. One interviewee demonstrated the way in which unsighted children are encouraged to make a clicking sound with their tongue while walking, or just after entering a room. The intention is to excite air in the room by making a short, sharp impulse that allows the acoustic qualities of geometries and surface materials to be perceived. This became the basis of the acoustic moment *Impulse-Response.*

One might assume that colour and shape are readily identified and described by the majority of the population due to the cognitive ability of vision being more easily adapted than auditory ability. Anybody who has raised a child will be aware of the daily experiences required so that children learn to identify discrete colour and form. Blesser notes that the skill of echolocation is, in part, a learned one (Blesser 2001, p. 888). It is then, not cognitively impossible for a sighted person to learn to quite literally hear spaces in fine details. It remains not an issue of ability but of acculturation.

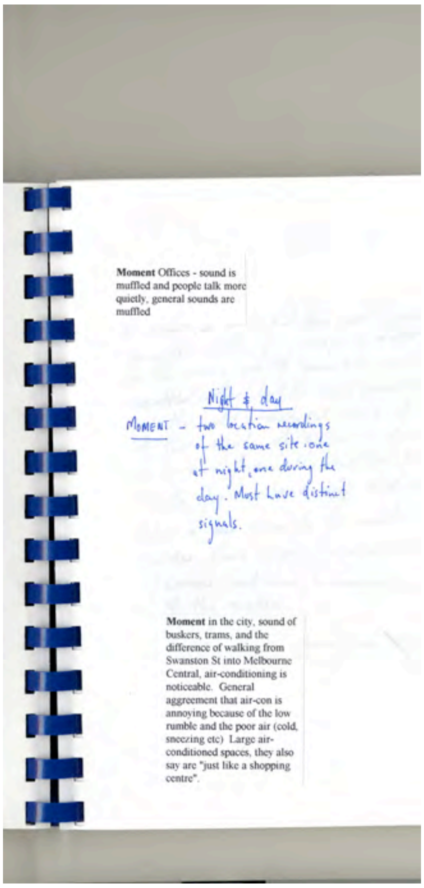


Image 40: SoundSites *work book*

An early page of the SoundSites *workbook showing notes for three possible acoustic moments. The first (top of image) was eventually discarded. The second (centre of image) was in the final exhibition, and the third (bottom of image), although not a specific moment, can be heard in several of the urban type moments.*

Throughout the interview and production processes, I had resisted the idea of recording a tapping cane. It seemed a trite resolution, too obvious to consider. A further reason for avoiding this arose when a mobility trainer commented that proper use of the cane was to provide tactile, not auditory cues. The mobile unsighted listener is meant to listen further than the cane, to scan the immediate surrounding environment for other sound cues, as opposed to using the cane as an impulse, exciting the immediate sound field, and listening to the result. The cane is meant for very near field tactile awareness, while the ears monitor middle and distant space. During an interview, a participant described the experience of walking through the city, tapping his cane on difference surfaces as being akin to a conductor, tapping out a symphony.

The succinctly playful, poetic image created by this comment provided welcome relief from the tension created by attempting to avoid the obvious. On a Sunday morning, I returned to the centre of Melbourne and staged approximately ten to fifteen recordings of the participant's cane tapping on concrete stairs, bluestone, road, paving, footpaths, grills, brick walls, lamp posts and gutters. The final text for this acoustic moment is as follows:

> 'I feel like a conductor bearing out a symphony on the city.' Sonic textures roll under Philip's cane as he navigates his way through the city. A rapid montage of clicks, scrapes and clutters.
> (Text from *SoundSites* exhibition panel No.1)

The final moment for the Exhibition presents a rapid montage of material. In reality, it would be highly unlikely that someone would traverse the number of surfaces presented in this 1 minute 47 second example. However, the idea was to compress a variety of auditory textures, to heighten the auditory difference in the surface materials encountered in a city.

Symmetry was a moment arrived at after several of the older participants spoke about 'small' and 'large' sounds. The text from the Exhibition's descriptive panel is:

> Two moments of symmetry: a church bell and the electronic beep of a handy teller machine; ocean waves and the hiss from an opening drink bottle.
> (Text from *SoundSites* exhibition panels No. 2 & 3, *Symmetry*.)

Interview participants expressed a desire for a soundscape that allowed for small and large sounds, creating a rich and complex acoustic environment. My own interpretation of 'large' or 'small' is through propagation, that is, the distance over which a sound will carry. From the types of sources described by participants, small sounds had lower amplitudes, while large sounds were decidedly louder. In acoustic ecology, a balance between small and large sounds is termed a 'hi-fi soundscape', "where all sounds may be heard clearly without being crowded or masked by other sounds and noise".[105] In *Symmetry 1*, the pitch of the two sounds is quite close, although the bell has more than one dominant frequency. I found the examples to record very close to home. At the time, I lived half a block from a church. The bell was rung only on special occasions such as weddings, which were common on Saturdays in this church, as the ornate interior was attractive to many couples. As the bell-ringing occurred only one day a week, it was an unusual sound mark of our community. Close to the church is a bank, which I happened to visit one afternoon, and was withdrawing money from the automated teller

105 From <http://www.sfu.ca/sonic-studio/handbook/Hi-Fi.html>, viewed December 6, 2006.

machine (ATM) just as the bell rang. I immediately realised the juxtaposition of a large sound and small sound, as described by the participants. I recorded the examples separately, however the bell is recorded in the grounds of the church, and the ATM from immediately in front of the machine. The two recordings were post-produced into a single recording.

Symmetry 2 is based on a remark from a teenage participant describing that the 'hiss' of a drink bottle reminded him of the 'hiss' of waves. If you listen carefully to the moment that a wave is dissipating on a beach in shallow water, a hissing sound can indeed be heard. It is remarkably similar to the 'hiss' from a drink bottle. In this instance, I cross fade between the two examples. I understood his comments to be acutely perceptive, and displayed both auditory memory and association of sound types.

Impulse-Response 1 is recorded from a simple exercise used by younger unsighted people to locate doorways, or test the dimensions of a room. As they mature, many unsighted people develop acute skills in echolocation, and simply listen to reflections caused by impulses such as voices, footsteps, clothing, rarely making the tongue click. The title was deliberately chosen to reference the process of computer-based convolution used in technologies for acoustic modelling of architectural space.

> Listening to a doorway.
>
> Find a doorway, move to one side, standing very close to the adjoining wall. Make a 'click' with your tongue and listen. Now move directly in front of the doorway and make a click, listen to the difference. An example is given here of a simple exercise in listening to space (Text from *SoundSites* exhibition panel No. 13, *Impulse-Response 1*).

Well-heeled was created in response to several observations about clothing, wealth and sound. One interview participant related the ways the sound of footsteps in the city changes with the seasons; faster and densely clustered in one season, languid and spaced in another. These two moments contrast the sounds of shoes with some allusion to film's Foley sound. The emotional range of footsteps is large, from the ominous slow pace and deliberate pause, to the quick scuffle of a rushing character in high heels. The speed and quality of sound of footsteps can denote benign presence, anxiety or a relaxed approach. The final text panel for *Well-heeled* is inscribed thus:

> The sonic character of a location is coloured by the affluence of those who visit. Wealthy suburbs are often quieter because of more expensive and aerodynamically designed cars, the tree-lined streets and gardens.
>
> Are dress codes audible?
>
> The first recording was made at the entrance of a hotel on Collins Street, the second was made at the entrance to a university campus on Swanston Street. Leather soled

shoes traverse the entrance of the hotel, while at the university rubber soled shoes create a different ambience.
(Text from *SoundSites* exhibition panels No. 21 & 22, *Well-heeled*)

The recording on Collins Street in central Melbourne was made at approximately 5 pm on a Friday afternoon prior to an Australian Rules Football Grand Final weekend. The street was busy with groups of people arriving and leaving the hotel premises for a pre-Match party. The steps sound determined and confident. The breaks between groupsset-up an expectation of the next cycle, in which traffic and the voices of mobile phone conversations can be easily heard. The University recording was made a few days later, during a lunch hour to ensure a busy time of day was captured. The reverberation of the foyer is perceptible, so too are voices moving past in an almost disembodied manner as they are rarely accompanied by the sound of their footsteps. Another unsighted interviewee commented that: "everyone has their own signature footstep. If you get to know someone, you get to know them by their footstep. "

Transitions - outside to inside presents a sonic transition familiar to many sound-based artists, and one that could provide a rich experiential technique for architects and designers. The transitions recorded here are closest to the CRESSON sonic effect of the *cross-fade* (Augoyard & Torgue, 2005, p. 29). Changes in reverberation characteristics between spaces are an important navigational cue for the unsighted walker who listens for the changes in reverberation time caused by spatial dimension and surface finishes that imprint space with a unique sonic quality. Transitions between reverberant types might also mark the distinctive qualities of structural divisions within an electroacoustic work.

> Transitions from outside to inside in three different arcades in the city. The variations in ambient sound between spaces form contours on a sonic map.
>
> A small difference is heard between the ambience of the street and the interior of the first two arcades. In most contemporary shopping malls, sound bounces around their interiors in a way that 'de-localises' the listener. The experience is a combination of blandness and frustration. The first arcade is flooded with machinery noise from outside. The soft hissing sound in the second arcade comes from nearby escalators.
>
> The final example is an older style arcade, high ceiling and several types of surfaces that reflect the sound away from the listener. The difference between the busystreet to the interior can be clearly heard.
> (Text from *SoundSites* exhibition panels No. 16, 17, & 18, *Transitions - outside to inside*)

Transitions records the gradual changes of moving from a street to the sensation of closure just inside the entrance threshold in three different building types. In *The Sonic Shoreline,* a similar navigational feature is recorded, the dips and troughs in the sound image caused by a series of doors and walls. Both these comments suggested that moving recordings with small text cues on the descriptive panel to guide the listener would provide enough information for them to focus on the key qualities of the recording. Yet another example of building envelopes affecting change on the soundscape comes from the time differences of sound reflections from various building setback distances. An interviewee described in detail the auditory effects of the setbacks on adjacent buildings in Melbourne.

> I used to be able to focus on the smaller sound, like the entrance to a restaurant because of the rattling of cups and [voices] ... Or, the fact that a particular building is set back ...
>
> Has anyone talked to you about being able to hear doorways and lanes? ... Using that [echolocation]... you can tell whether the building is on the street, whether it's back a bit, whether it's back a bit further, or whether it might be a laneway because you can't hear the building. I use that a lot for identification, particularly if I know buildings; I use that a lot for identification for where I am, or for what I'm looking for. You can even do that to a certain extent with doorways ... (*SoundSites* interview participant)

5.6 Attitudes and awareness in diverse auditory milieux

The idea of *CitySounds* as mirroring a quotidian auditory experience in a city is reflected in the types of spaces that one might occupy in that day through the course of daily activities in, for example, an apartment, a café, a site-of-respite, a nightclub. In traversing the city, moving between these sites, one would further experience the soundscape of a street with loudspeakers, noisier or quieter areas, air-conditioners and construction sites. As with *SoundSites*, the organisational principle at work is that of a listener traversing acoustic environments. In this section, I will analyse key findings from the survey to identify different attitudes, and the type of awareness the respondent group reported to sounds in Melbourne.

Loudspeakers

There are seven questions in the survey specifically related to amplified sound. The general attitude arising from the results is not that loudspeakers should be banned, but that the spatial projection, or impact of loudspeakers should be limited. In two sites, or instances of particular settings, the results indicated that given the choice, people would prefer a reduction in loudness, rather than the complete removal of loudspeakers. The first type of loudspeaker source is that at street level, as used by buskers, spruikers and at shopfronts. Over half the respondents reported that removing loudspeakers would either 'extremely', or 'somewhat diminish' the vibrancy of the CBD. But although loudspeakers are considered a positive contribution to the experience of the City, it is the loudness level of these sound sources on which respondents were substantially in agreement. In a question measuring the distance at which a loudspeaker should be heard, 75% of respondents selected 'less than five metres'. Localising the impact of loudspeakers to this distance, which is the equivalent of approximately eight walking paces, or the confines of an average shopfront, would potentially create acoustic conditions quite different from current ones. In Melbourne, projection by loudspeakers across a street is common.

By far the most surprising results related to loudspeakers were for those used in nightclubs. The largest demographic to respond to the *CitySounds* survey was aged less than 35. Of those, over two-thirds had visited nightclubs in the previous three months and reported that it was loud. While just over half reported that they enjoyed loud music, 89% believed that music should be managed in a venue so that it is loud on the dance floor, but heard at a volume elsewhere in the venue so people can hold a conversation. This is a significant result, and one that could challenge accepted beliefs on amplified music in nightclubs, to wit that loud music is an integral part of the experience enjoyed by all patrons. This issue is similar to smoking bans in bars and restaurants, where industry associations and the tobacco industry held that bans on smoking would be detrimental to business. The opposite would appear to be true, according to *The Sydney Morning Herald*, 'Smoking bans do not damage pub trade: study', (February 26, 2003, p. 5).

The technologies for amplified sound have reached a stage at which the manufacturing costs for individual loudspeaker units are so low, their end-user affordability has made them an ubiquitous presence in the soundscape. Ivan Illich warned that:

> Just as the commons of space are vulnerable, and can be destroyed by the motorization of traffic, so the commons of speech are vulnerable, and can easily be destroyed by the encroachment of modem means of communication (Illich 1983, p. 19).[106]

Illich's position is that the proliferation of communications technologies, of which the loudspeaker is a prime example for communicating over extended physical space, are technologies that encroach onto the public space of the acoustic environment in a way that robs individuals of their equal voice. Despite the apparently clear opinions and preferences held by *CitySounds* respondents, it is interesting to consider how often people tolerate annoyingly high levels of sound from a source that can be easily moderated with human intervention. Why not ask that the music be turned down? Perhaps this situation of uncomfortable toleration arises from how and when an individual can assert their auditory rights. While a customer has an expectation of what changes they may demand to the environmental conditions of a restaurant, for example – the lighting levels altered, air conditioning adjusted, or a window opened or closed – it would seem to be the sole right of the restaurant operator to determine the acoustic conditions of the space.

Noise and Sound

While the formal definition of noise is 'unwanted signal', the *CitySounds* survey did reveal the manner respondents translate this technical term into everyday attitudes.

106 Illich, I, 'Silence is a commons', viewed November 22, 2006, <http://www.preservenet.com/theory/Illich/Silence.html>.

Throughout the survey, the words 'noise' and 'sound' were interchanged. I suggested this to Council as a possible way to generate broader ideas about the soundscape and to assist with preparing the way for a question that would give some indication on respondents' awareness of the difference between the two words. When asked to select from several definitions of 'sound' and 'noise', over half of the respondents selected the multiple-choice answer: "It depends on what I am doing whether something I hear could be a noise or a sound." Context is accorded a high status in determining the difference. In other questions related to annoyance, the results showed that people were most annoyed by sound, depending on the degree to which they must limit external stimulus for what might be called interior activities: sleeping, reading, having a conversation (Harvey & Leong 2006, p. 32). Similarly, respondents were aware that their emotional state also played a role in their response to sounds as a level of annoyance (Harvey & Leong 2006, p. 31). Being stressed, angry, physically unwell, tired or upset were all interior states which respondents selected as causing them to be more easily annoyed by sounds.

To influence behavioural change of the community, a government agency would benefit from knowing the existing awareness of the target community to the soundscape. In this case, it is the awareness of the general public as to when they are least, or most likely to be annoyed by sounds. In some instances, alleviating annoyance does not require a technological or legislative intervention. A process by which behaviour and 'and/or' motivating attitudes might be changed in people whose actions affect others in communal space for example, would achieve some change.

Respondents almost unanimously reported (94%) that quality of life would be improved if the level of sounds entering their homes was reduced. This attitude could provide a useful motivator to any initiative, campaign or other opportunity presented to the community to improve their auditory conditions. While an initiative may not directly involve improvements to dwellings, it could be used as an indicator of willingness for people to participate in modes of behaviour that lead to improvements in their exposure to loud sound. Respondents also thought that legislation would best address noise modification issues.

Acoustic conditions in cafes

Following the wave of European immigration immediately after World War II, and continuing multicultural immigration patterns over the ensuing three decades, Melbourne's dining culture has earned an enviable reputation in Australia for excellent coffee and a diverse culinary environment. Melbourne's liquor licensing laws also differ from those in other major Australian cities, making it easier for even small cafés to serve alcohol. One result is a vibrant inner city bar and cafe culture.[107]

The results for café questions showed some consistent attitudes but differences in awareness. Respondents aged over 35 years selected construction materials of glass and concrete as being the main contributors to increased noise levels in cafés. Those under the age of 35 thought the noise increase was attributable to music being played at too loud a volume.

107 See <http://www2.visitvictoria.com/displayObject.cfm/ObjectID.00002588-C2A9-1A67-88CD80C476A90318/lk.Centre3_1/pg.MelbGateway/vvt.vhtml>, p. 6, viewed October 12, 2006.

Without the benefit of a more extensive architectural survey of cafes in the CBD, I can make only an anecdotal observation that few café building-designers consider the acoustic performance of spaces, compared to the time and attention taken in selecting visual materials of the interior design, such as paint and carpet colours, surface finishes and lighting conditions. A small part of the complex picture influencing auditory spatial experience in cafés in the same geographical location and population as *CitySounds*, is revealed by Rohrmann (2003). His research seeks to understand the soundscapes where people eat, with particular reference to the effects of music. He reports that "loud soundscapes are liked, or at least tolerated, and quiet situations not much searched for" (Rohrmann 2003, p. 1). Rohrmann's study combined interviews, questionnaires and sound pressure level readings made in cafés. Although a small sample was used for the survey, another finding was that "the sound levels in the cafés and restaurants looked at in this study are not in line with regulations and recommendations" (Rohrmann 2003, p. 6).

CitySounds contained two questions about expectations of acoustic environments in cafés and restaurants. These questions were also structured to inform Council of the extent noise complaints were indicative of general community attitudes, or if they were unusual. A large majority (89%) have an expectation that sound levels will change depending on the type of café or restaurant. Respondents also reported different expectations held for different occasions. While this might first appear as a self-evident result, it is interesting to note that nearly three quarters of the survey base also state that noise level is a factor in choosing a particular café. While menu, standard of cooking and price of food are also expected to play a part in these decisions, the perceived auditory conditions they are likely to encounter, and possibly, the levels patrons wish to tolerate are also a consideration for people. In further analysing motivations for behavioural change and use of other resources, two-thirds of people reported that they had recently been disturbed by noise in cafés, and still more responded that they would use acoustic-related information to regulate their dining pattens.

It is unrealistic to consider that a majority of restaurants and café owners would retrofit their premises. A research project could identify cafés and restaurants that have some acoustic design features, and are managed in a way that is considerate to patrons' needs for acoustic communication. On a city-wide basis, change could be enacted by either building a sound assessment into the star rating system of newspaper restaurant reviews, or provide a website combining favourable auditory reviews of dining experience and the contributing factors to that experience.

Awareness: air-conditioning and general sound on the street

The impetus for questions on construction and air-conditioning noise was based on complaints received from residents. Starting in 1992, the Postcode 3000 program in the CBD of Melbourne aimed to produce an additional 3000 apartments in the central city by 2000.[108] Between 1996 and 2003, the residential population grew from 39,716 to 58,031 (Australian

108 For further information on Postcode 3000, see <http://www.melbourne.vic.gov.au/info.cfm?top=288&pg=1362>, p. 6, viewed October 18, 2006.

Bureau of Statisitics Estimated Resident Population). Daytime users are estimated at over 671,200 persons, comprising workers and visitors.[109] The competing auditory needs of these users and residents have been great. Apartments are located in mixed-use precincts, amongst business, bars, restaurants, or nightclubs and offices. Many of these operations have plant and equipment, usually located on rooftops. This machinery exists for air-conditioning, cooling for computer server rooms, or extraction fans for commercial kitchens. In some instances, the purchasing of apartments from plan meant future residents did not visit the immediate acoustic conditions of their new dwelling, as reported in *The Age*, 'How inner-city blues hit home for new apartment dwellers', (May 4, 2002). (please credit Author William Birnbauer). While the times of operations vary, the auditory effect is usually the flat-line sound of acoustic ecology. Cooling units on server rooms might not commence operation until evening continuing overnight, when back-up routines being run on large computers require the most cooling. Commercial kitchens opening at night will require extraction fans to operate when residents are likely to be seeking quiet for sleep.

Over half the respondents reported some awareness of air-conditioning in homes, the street, place of work or study, or in cafés or restaurants.[110] While the survey did not test the level of annoyance of this sound source, the result suggests that it is a pervasive one to listeners in the environment. My own listening experience in Melbourne suggests that it is difficult to find an urban space absent of machine noise. Seventy percent of respondents were annoyed by sounds between once or twice in an average day, and up to every time they were outside. Almost the same number (68%) said they did not avoid parts of the CBD because of loud sounds. In the Report, I suggested this was because the physical conditions and information to do so were not present, but should form the basis of an urban acoustic design strategy. This is discussed in the following section. Respondents were also asked to name sites in the CBD that they perceived to be quieter than others. The list included libraries, some arcades and laneways, gardens, churches and selected cultural institutions. These sites are situated either away from major arterial roads, or in the case of churches, protected by solid construction.

Sound in apartments

The way apartment sound was dealt with in the survey was to present listeners with three rooms, and similar sound events. The events heard in each room were processed using different parametric equalisation curves to simulate the effects of different sound-proofing on known annoying sound sources. The sources included shouting, bottles smashing, amplified music, banging garbage bins, a reverse beeper and hydraulic sound on a truck. Almost 90% of people heard these sounds in their current residence as a weekly and sometimes daily

109 Figures from <http://www.melbourne.vic.gov.au/rsrc/PDFs/Multicultural/Socioeconomic.rtf>, viewed October 18, 2006.
110 To manage a quieter acoustic environment in my own university office, I would put a Macintosh G4 desk-side computer to sleep, and connect a laptop to the main screen. The compromise for a quieter working space, is a single screen, but still requires that I transport 2.8kgs of computer between home and office. The computer has now been relocated outside the office. Recently, I cut a small gap in the lower part of a door, and extended cables to relocate the G4 outside the office, which was a vast improvement.

occurrence. The first room was untreated, the second had better-rated windows and walls, and the third had a high acoustic rating.

The sounds that rated in annoyance most highly are all the result of individual's behaviour in the course of recreation or work. While there is a technological and material component to these sound sources as well, individual action would reduce some impact of these sounds. Shouting and bottles smashing rated most highly, the latter usually the result of the admirable environmental action of recycling for glass.

At the point of sale, or renting a property, over 80% of respondents reported that acoustic design features were important to consider. For the final report, the analysis produced used this result to suggest that any information campaigns be targeted toward the public at this time, as a critical information gathering and decision time. In relation to acoustic design features on houses, a majority of respondents also felt that legislation was the best method to address noise issues for apartments.

The listener-scale interventions and willingness to self-manage

Following analysis of several of the survey sections, I was able to state that results suggested a more sophisticated attitude in listeners to their acoustic environment than might generally be assumed, and an underlying interest amongst respondents in audible change to CBD locations. Related to these findings were survey questions to determine the degree to which individuals would self-manage their relationship to the soundscape. That is, to what degree would individuals self-manage their daily experience, or exposure to the soundscape if offered design interventions and information resources to do so? The question was investigated through subtopics. In the opening socio-economic questions of the survey, we asked people how often they walked in the City for different purposes. We wanted to ascertain the degree of people's mobility in the City, or do they 'cocoon', moving mainly between work and home. These questions were also intended to assist other questions seeking possible general locations for sites-of-respite. A majority of the respondents reported that they dine out, walk in a park or by the river, or drink in a bar at least once a week. Almost one third said they walked to work, and a similar number said they walk for relaxation daily. I had also observed in general conversation that people were able to accurately locate City places and situations where they experienced intolerable sonic conditions. This knowledge is either accumulated through personal experience, or through anecdotal suggestions from others. The survey contained questions asking respondents to identify quiet and noisy locations, as a way of determining the degree to which an awareness of the soundscape was generally prevalent in respondents.

Soundscape studies define the listener as the basic unit of acoustic design. Schafer compares this to the techniques of architects using the human anatomy as a guide to the scale of objects and structures. He sees the human ear and human voice as providing the benchmarks by which we should determine the scale of the acoustic environment (Schafer 1994, p. 206). He observes that:

> … when … environmental sound reaches such proportions that human vocal sounds are masked or overwhelmed … when sounds are forced on the ear which may endanger it physically or debilitate it psychologically, we have produced an inhuman environment (Schafer 1994, p. 207).

I used the term *listener scale* in the *CitySounds* report to describe a series of linked interventions and resources, through which a listener can self-manage their auditory exposure to detrimental acoustic environments. The idea of listener scale is an attempt to reposition thinking on urban acoustic design away from a 'whole of city' approach to noise issues to one where the city is considered as series of linked and embedded auditory experiences.

The listener scale approach is one in which urban design might be used for two outcomes. The first includes design and management interventions that result in real changes to discrete milieux or micro-environments of the global city soundscape. The second is to make information about these places and spaces available to residents, workers and visitors to a city. I have purposely excluded workplaces and private residences from the following examples and discussion. Modifications to these structures are the responsibility of private or corporate owners. While they must follow codes during construction, post-occupancy modifications demanded by a local government would prove logistically laborious andhighly unpopular. For this reason, a program to provide modified acoustic conditions in Melbourne should concentrate on spaces, places and business operations that Council might affect. For example, many of the laneways in Melbourne are subjected to air-conditioner noise or amplified music, although wellisolated from most traffic noise. Similarly, some cafés have acoustic conditions that make conversation difficult, while of course, many do not. Compared to the engineering required to reduce noise on roadways for example, the noise sources in laneways and cafés would not require major efforts to reduce impacts on the acoustic environment. Once modified sites and acoustic conditions are established, then the public would require information to self-manage their daily use of the city around these modified sites. Similarly, once a site-of-respite is established, information is required to access it. A comparison of how acoustic interventions, or resources might be accessed at different times of the day is shown in Table 30.

Time of Day	**Intervention-Resource**	**Comment**
Morning	Quiet walking routes	Individual listeners reduce exposure from street-based sounds.
Lunch	Site of respite	Somewhere a listener can visit for quiet.
Dinner	Access website for information on quiet cafés-restaurants	Access information on where to dine quietly.
Evening	Access website for information on bars and nightclubs	Visit a bar or nightclub where it's still possible to hold a conversation, and not be exposed to loud sound.

Table 30: CitySounds *time and listener scale interventions*

The questions directed to locations suitable for a site-of-respite were structured to provide some broad indications of likely use by residents, city workers and visitors. Three questions were used to determine frequency of use relative to location, visitor frequency, and activities during a visit. Only one in four respondents said they would 'never', or 'rarely use' a site-of-respite if it were located five minutes from their office or home. As the City of Melbourne estimates that over 600,000 visit the City daily[111], there is a high potential that any designed site offering quieter conditions has a large catchment of users. Just over 60% of respondents indicated they would use a site-of-respite for quiet, relaxing activities such as eating lunch or meeting a friend for coffee. Few responded that they would use such a site on the weekend, before or after work. This result has implications for future management strategies of a site. To avoid vandalism, it could be locked on weekends and after hours. The more generalised question on frequency of visitation revealed that nearly 70% of respondents would visit at least once a week, or more often. In general, the results indicate a high degree of interest in the provision of urban design features whose primary function addresses acoustic conditions of the city. This topic is further discussed below with reference to current and proposed noise strategies in London, New York and Melbourne.

Auditory qualities of spaces including echolocation

As an art-based project built by investigating auditory knowledge of unsighted people, *SoundSites* revealed qualities of spaces and navigational strategies. An alternative approach to the Project might have been to use survey questions or acoustic measurement and analysis approaches. However, I don't believe this would have been generative for the intended project culmination of a sound-based exhibition, and to create an auditory ethnographic document. As a process of consultation and creation, the Project could focus on subtle attributes of the environment and listener experience, and treat the acoustic environment as a series of interconnecting milieux, a continuum of listening in the environment.

Auditory spatial skills in a few of the participants were impressive, and I referred to them as '*soundscape virtuosi*', recognising their ability to discern and use acoustic energy in building a spatial map of their environment. As evidence of this, I will briefly discuss several auditory features of the built environment, as revealed by selected interviewees.[112] The first instance was a female participant, blind since birth that used the time and spectral differences of reflections, attributable to building set-backs to navigate along a busy street.

> I don't know whether you know that 500 Bourke St. is set back from the street, but it's not set back as far as [the building at number] 570. You can actually tell that difference of how far the shop or building is set back from the walk area.

111 Figures from, 'Revised 2004 & 2006 City User Estimates and Forecasts Model 2004-2020', p. 4, from <http://www.melbourne.vic.gov.au/info.cfm?top=91&pg=2297#how>, viewed December 6, 2006.
112 Original interview tapes and transcriptions are held by the Author.

In another instance the difference is caused by the disparity between sound reflections from steps and a flat surface. The Post Office also has arches that may contribute more of a hollow sound to the streetscape:

> … But also the Post Office steps [corner of Elizabeth and Bourke St Mall] have their own, very particular sound as well. So, you can tell when you get to Myer because the building comes back to you after the Post Office has been set back … [and] because it has steps, it has a slightly different sound …

Yet another participant explained the effect of the changes in shopfront design from 19th Century *bull nose*, or curved entrances with open doors, to flat surfaces and sliding doors with motion sensors. In a streetscape composed of the traditional design, the auditory result of walking past a series of shopfronts was a type of wave motion; each open entrance would funnel the interior sound onto the street with a subtle 'fade-in' and 'fade-out'. The commercial activity would reveal different mini-soundscapes, a café or restaurant through the 'chinking' of crockery, or the muffled ambience of a haberdashery shop. The modern sliding doors create a quite different auditory experience. As the motion sensors only cause the door to open just at the point of passing, it is only human presence that suddenly reveals the interior. It is as if the sound is appearing and disappearing behind acoustic shutters. It is this aspect of the streetscape and the transitions in and out of different building types that I attempted to capture in the acoustic moments *Sonic shoreline* and *Transitions 1, 2 and 3.*

Adult participants often mentioned the concept of balance. It is important to acknowledge that although many commented on how noisy many environments were, that the 'big' sounds would overwhelm the 'small', it was necessary for successful navigation to have a combination of absorption and refection. Acoustic reflections tell the unsighted listener about geometries, while occlusion of reflections reveals objects in space, and sound absorption about the material qualities of different surface textures.

There is piece of accepted practice in urban design that a water feature will solve noise issues. For a time, a central Melbourne square was home to a large water feature, intended to provide a masking of traffic sound. However, one participant had a strong reaction to this acoustic intervention.

> … I hate sounds that mask and keep going [are continuous]. I loathed the City Square when they had the water [fountain], there was this screaming noise of water so you couldn't hear where you were and you were very unsafe. Because it just obscured every other sound … everyone said, 'Oh water, lovely'. It was ugly, just ghastly. They have just looked at it, not listened to it. It was just [an] ugly 'mess' sound … It would have been like for other [sighted] people just like lights flashing so you couldn't see anything.

An interesting piece of advice for urban designers can be gleaned from this quote. The critique of the fountain is primarily one about redundancy and dominance of auditory information from the fountain. Designing a water feature that could modulate its spectral qualities would be one solution; for example, by changing the interrelation of the cubic volume of water per unit of time, depth at location of drop point(s), and whether the water strikes a hard surface or a pool of water. A participant who was gradually losing her sight also described effects of disorientation.

> … In the last year or so as I find my sight getting worse, I get very disorientated … All the noise in between is difficult [when I am moving between locations] … Internally, if I get confused with my hearing, my eyes go funny. I get agitated. If you're hearing gets overwhelmed, there's nothing else to rely on.

Echolocation

Blesser gives an account of various formal studies and anecdotal reports on echolocation abilities (Blesser, 2006 pp. 35 - 46). I found participants used both the terms 'echolocation' and 'facial vision', while others were not aware of either term but did practice auditory spatial awareness at a highly skilled level. Blesser notes that the term 'echolocation' is used for all forms of spatial awareness, but was first applied to studies of bats and dolphins, both of which have the ability to vocalise and then decode the returning echoes. Unsighted people predominately use background sound to sense spatial attributes, and not just echoes but other acoustic cues as well, such as low-frequency tonal colouration to detect walls, especially if the sound source is continuous and the wall nearby. In addition to a review of the current scientific literature on echolocation, Blesser also notes the following aspects of the skill of echolocation, it:

- is not conscious, as 'even those who have a highly developed skill cannot describe how they do what they do'
- requires great courage to use
- is an unusual form of navigation, at least at a high level of performance as most blind people rely on the tactile sensations of a cane, '…using echolocation only as a supplement to their tactile sense of space' (Blesser 2006, p. 38).

Most listeners possess a rudimentary auditory map of at least one environment. The thousands of hours required to build an auditory spatial map of an environment can be undertaken in ones' home.[113] When first describing how spaces have auditory signatures, I ask people to recollect the difference between the sound of their bedroom, their lounge room, and bathroom. The skill of using spatial cues is latent in the majority of people, not through a lack of ability, but through an absence of learning.

Several unsighted participants offered descriptions and insights into their ability to echolocate. One older woman referring to 'facial hearing' said her glasses interfered with her

113 For instance, assuming a minimum time spend in the home is 5 hours per day for 7 days a week, for 48 weeks per year, then 5 hours x 7 days x 48 weeks totals 1680 hours per year.

ability to perceive sound in this way. Another unsighted teacher described it as creating a sensation across his forehead, while another male said,

> My hearing is going down a bit, and you use the high frequencies for echolocation. Some people call it 'facial location', but I think that is a misnomer. You sort of feel, you get the impression of feeling there is a wall there [puts his hand out to an imaginary wall] … you can't hear something that is silent, but what you're hearing are the noises that are in the kitchen [for example], and because of that, you can 'hear' the wall is there.
>
> I suppose you do turn it on and off, or don't bother. I suppose it's like wearing a watch, it's there when you want to know what the time is, but you're not conscious of wearing it …

SoundSites *audience comments &* CitySounds *participants closing responses: ethnography*

I have been considering the responses of unsighted listeners to the acoustic conditions of built spaces, but what of sighted listeners? In the *CitySounds* project, there were several places where survey participants could enter text descriptions, prompted by questions of the type: 'In your own words…', or invitations to 'Please make any further comments'. In the *SoundSites* exhibitions, visitors' books were used to gather similar text-based descriptions. Therefore, opportunities for audiences and respondents to provide feedback were built into both projects. Unfortunately, due to an unforeseen technical issue, the responses for *CitySounds* truncated to approximately words.

In Section *1.3 Toward the design of acoustic space*, I introduced Feld's notion that soundscape composition should be an essential form of communicating acoustic environment research. The role of sound in both *SoundSites* and *CitySounds* conforms to Feld's notion by not only reflecting the acoustic environments under investigation back to listeners, but also by taking us on a journey through those environments. The intention behind the structure of both projects is similar – to replicate the sounds of various acoustic environments a listener might encounter in daily life in a city. Time is, of course, compressed in both projects: *SoundSites* is fifty-five minutes and *CitySounds* approximately twenty minutes. It is the sequencing created by traversing different environments that I believe contributes to the communicative impact of using sound as an interface in this way. The comments provided directly by audience and survey respondents in both projects are considered as evidence of this impact:

Many surprisingly familiar sounds, from a place I've never visited. Nice to hear the unusual ones (to me) as well.
Why are these sounds, supermarkets, traffic, people walking so comforting? Evidence that the world continues elsewhere, as well.
Surprising what we don't hear, when we can see.
I enjoyed re-listening to the everyday and being surprised by it through sound. It was a very interesting exhibit and listening experience. I found my aural and visual senses merging as I felt as though I was seeing with my ears … and I closed my eyes to block out 'white noise' from my visual surroundings. A fascinating and memorable experience. I will be revisiting in the near future. The panels enrich the experience.
A very 'ear-opening' experience. Enlightening thoughts on the socio-economic effects on sound environments and sonic 'sign-posts' and … of landmarks. Very interesting to consider the sound environment perspective of a blind individual.

Table 31: SoundSites *audience comments from Toronto exhibition*

An interesting and fun approach to a survey…
As a person of society this interactive sound survey has given me greater self knowledge as related to the understanding… [sic]
Creative use of sound effect on 3D architecture modelling for the environmental survey.
Excellent work SIAL, found it made me think!,
Found the noise the same all through. Someone walking along maybe the system was defective????,
Grease and oil the tram tracks for when they swap over, great idea.
Like to see more surveys on other topics.
Only improvement that when you walk into chimes area, make clear an alternate respite place is coming…
How about house and car alarms - very stressful noise pollution.
I hope this will go to some use improving our CBD, I think there should have been a section focussing on trams.
If a shop is playing loud music I refuse to go in. They play music way too loud,
Interesting way to coax information…
Make it faster and smoother.
Please make it possible to move more quickly throughout the virtual CBD, it was painfully slow.
I hope many residents give you feedback but somehow I doubt it, this is an excellent survey.
I am a different person, due to the realisation of what was obviously just normal…
Why make this so slow? Could be done in 1/10th of the time if it didn't have the silly walk thru [sic] the city…
Would be keen to see if any actions result from this survey.

Table 32: CitySounds *respondent text comments*

The *CitySounds* respondents obviously identified most closely with the sounds of the survey as recollections of their own experience in their local acoustic environment. While for those attendees in Toronto, there is a sense that the exhibition was a form of 'acoustic tourism'. The comments about the speed of the program in *CitySounds*; that it was too slow, or it should be made faster reveal attitudes to interactive media. Firstly, the sounds would 'whoosh' by if the program was even used at a running pace, and secondly, the survey in its entirety can be completed in twenty minutes. As discussed previously, it was intentionally kept at this duration as part of the survey design. Also revealing are the comments on the experience of everyday sounds, where audience and respondents alluded to a deeper appreciation of the sounds around them. These comments suggest that the use of sounds in both these projects has a result similar to the effect early surrealist projects visited on the attitude to the objects of daily life. In the sense that by placing everyday objects in art exhibitions and according them the status of *objets d'art*, different aesthetic criteria are applied to those objects by the public. Audience comments such as: "Why are these sounds … so comforting?"Or, "Surprising what we don't hear, when we can see", suggest a shift in the status of these sounds in listener's experience. This deeper appreciation of the sounds of our environment suggests a longer term project: to transform the sounds of our acoustic environment from the purely unintentional consequences of technological devices, or those that are purely *informational* to a richer palette of designed sonic objects.

Impact: CitySounds *and Urban Design Strategy*

The City of Melbourne pursues several roles in determining the visual experience of individuals in its city spaces and places. This is undertaken through guidelines, strategy projects and local laws covering lighting for decoration, safety and amenity, visual advertising, and graffiti. By way of example, the *Lighting Strategy 2002,* had objectives in line with a commitment of Council to "… make Melbourne an even more liveable and attractive city." (City of Melbourne 2002, p. 4). The *Lighting Strategy* aims to "…enhance people's experience of the city after dark", which is considered a part of the amalgam of factors, contributing to an individual's sense of wellbeing. The Strategy acknowledges Melbourne's characteristic brand of urban design as being a "public realm that is simple and low-key, but also elegant and clearly structured" (ibid). As an instrument to shape the urban environment, the Strategy seeks to augment existing codes of practice for outdoor illumination, and "helps to brief designers, but…does not prescribe outcomes" (ibid). Fifteen lighting issues are identified in the Strategy, divided across four themes[114] which themselves encompass aesthetic, design, logistic, and practical implementation of the Strategy. The Strategy acknowledgement includes individuals and companies from urban design, engineering, environmental consultation, planning and project management. Approved expenditure for the Strategy was AUD$1.6M in 2000/2001 (op cit, p. 5). Another AUD$7,146,000 was termed *priority* budget for the ensuing five-year period to 2005/2006, pending available funding. As yet, the City has not pursued a companion project on the acoustic environment.

In the City of Melbourne Urban Design Draft Strategy: *Toward a better 'Public Melbourne',* an analysis of the visual and auditory terms reveals a distinct bias toward the ocular. From an aural-centric perspective, it is commendable that early in the Strategy, sound is accorded a function in the experience of the city:

> Humans have sophisticated faculties of perception. While most of our information about the public realm comes to us visually and the stimuli supplied by most city spaces present an over-whelming bias towards vision, our ability to hear, smell, taste and touch our surroundings opens up rich possibilities for design. A more

114 The four themes are: Designing the Luminous City, Safety and Amenity, Attracting the Evening Crowd and Designing the Sustainable City.

enticing public environment will engage the 'hidden' senses and bring attention to textures, odours and the 'soundscape' of a city to create a vivid experience of public spaces and enhance their sense of place (City of Melbourne 2006, p.11).

Throughout the document, at least fifteen different terms and concepts associated with visual perception are present, summarised in Table 33.

Visual	access, cues, variety, benefits, detail, amenities, range, clutter, landscape, experience
Visually	coherent domain, impermeable, understood, connected

Table 33: City of Melbourne Urban Design Strategy (2006*), visual terms in the document*

In the Strategy report, 'Acoustic' appears twice, and 'quiet' four times, while the term 'noise' appears fifteen times through the Report. 'Sound' appears once in an extract from the *Arts Strategy 2004-2007* (City of Melbourne 2006, p. 48), while the terms 'soundscape' and 'soundmark' are both used in relation to providing, "enhancement of the urban environment for vision-impaired people" (City of Melbourne 2006, p. 37). The inference would appear to be that the sighted public do not require acoustic design interventions, although this point is further discussed below. The Report also contains discussion of legibility and the public's ability to 'read' an urban environment:

… A clear city structure is legible. 'Legibility' in urban design relates to people's ability to 'read' the urban environment – to interpret what they see to obtain useful information. As with reading printed language, legibility can be adversely affected if city spaces are poorly organised or cluttered, or if important information is hidden. A well designed city needs to be intelligible to its audience, the public, and responsive to needs … (City of Melbourne 2006, p. 10).

Furthermore, the possibility that sound might contribute to legibility, at least through a diminution of disorientating sounds is not considered. It is the physical conditions of the environment that coalesce to create audible navigational cues and that disorientation can be created once particular sounds, for example, a water feature producing a broad-spectrum sound, are intentionally placed in the environment. The metaphorical link to reading printed language without reference to the auditory is also curious, especially when considering the intended meaning of the printed word:

…the written symbol is a sound and only expresses its full value by its restoration to sound. Writing only carries meaning when the reader 'hears' the sound of the words in front of him (Tomatis 1991, p.89).

Legibility within the Strategy is also considered alongside accessibility as a dynamic and unfolding component of the environment. Again, listening to the acoustic environment is not considered part of accessibility, which:

> … includes visual access as well as physical mobility. This implies broad vistas, direct lines of sight or gradually unfolding views. Conversely, there are also opportunities where 'surprise pockets' can reveal themselves without being directly anticipated. Good visual access helps us to locate and comprehend a place, and directs our attention towards our fellow citizens. Visual cues attract interest, just as informal surveillance engenders a sense of personal safety. Without these invitations and reassurances, even the most comprehensive street system can remain impenetrable (City of Melbourne 2006, p. 11).

My intention is not to be unconstructively critical of the Strategy, but to demonstrate how visual bias is entrenched in professional thinking about the urban environment. The *Urban Design Strategy Report* included research from *CitySounds* in formulating strategies and opportunities for the design of areas of respite, and affording people more prospects to pause in the city, including a recommendation for a:

> … 'schedule' of areas that could be developed in the longer term as quieter pedestrian thoughfares and quiet spaces for the general public (City of Melbourne 2006, p. 37).

However, it is not just quiet places that would make a difference to our urban experience. In Melbourne, it is difficult to view a building of over three stories in height without the accompanying sound of plant and equipment. Why should this make a difference? On a conference trip to Vancouver, Canada in 2004, I walked through the new foreshore development in the early evening. This 'new world city' provided an auditory experience that I realised was lacking in my hometown - the presence of quiet buildings. In the absence of a dominating noise source, the viewer and building share an acoustic arena, that is; the auditory space devoid of plant noise situates an observer in a cubic volume congruent with the visually perceptible scale of the building. One feels more drawn into the volume of the building, not overwhelmed by the acoustic energy spewing from plant and equipment of the building's functioning.

In 2006, Council House 2 (CH2), Melbourne City Council's landmark environmental building opened.[115] The effect of observing this building from the street is subtle, yet prescient to the difference a quieter spatial condition would have on listeners. The street access for the building opens up to the sounds of motion – footsteps, voice movement , cars, and bicycles. Test sites are required, exemplary locations where decision makers may themselves experience the difference *in situ*. It is difficult to model, project, let alone imagine the full extent of an acoustic design effect. As Blesser notes, "there is no aural equivalent to a picture book of visual architecture … our culture cannot readily communicate its aural architectural heritage" (Blesser

115 See http://www.melbourne.vic.gov.au/info.cfm?top=171&pg=1933, viewed November 29, 2007.

2007, page 17). While computer music techniques will be useful to this task, it is the confluence, the combination of artistic, design; perceptual and functional thinking that is critical.

Conclusion : toward a community of practice

SoundSites and *CitySounds* reveal aspects of the auditory spatial experience of the sighted and non-sighted listeners of Melbourne. The formal organising structure of both projects – linked milieux traversed by a listener – is the basis of a strategy I propose for acoustic design in urban settings. Ensuring that a listener can self-manage their qualitative experience, or compose their exposure to different sonic conditions in the built environment is essential. The *listener-scale approach* builds on the awareness and experiences reported by listeners in this chapter, and involves informational resources to link the currently used technological, legislative and constructed methods for affecting change in urban acoustic environments. Early impacts of this concept have appeared in the 2007 draft of the *Urban Design Strategy* for the City of Melbourne.

The application of sound as the primary representation of acoustic space to create, or reveal auditory spatial experience has been described throughout this thesis for discrete projects. But for an auditory perspective on spatial discourse to advance across design cultures, a community of practice must evolve through which the ephemeral nature of the audible can be continually made present, not just to design researchers and practitioners, but also to the general community. The two project modes discussed so far, are examples embedded in a larger project of an electroacoustic studio in a school of spatial studies, which will be discussed next. The Studio, and its community of users are responsible for making the audible present through teaching, research and cultural events, and it is a place to support a series of interconnected practices, positioned along a spectrum of auditory design practices.

6.0 The electroacoustic studio in a school of spatial studies

Good design is intelligence made visual.

(Stephen Bayley interview broadcast on *By Design*, ABC Radio National, Saturday 11th November 2006, attributed to Le Corbusier. The interview was titled, '*What role the superstar in design?*')

Introduction

Throughout this thesis, I have avoided discussion on the relative merits, and perceived dominance of one sense over another, particularly the relationship of the visual to the aural. There are two reasons for this position. Firstly, most observers are simultaneously 'viewer' and 'listener' both, and engaged in haptic and olfactory sensing of the world as a complex of experiential stimuli synthesised at the moment of reception. A complete understanding of how the senses merge stimuli (*multisensory fusion*) at the neurological level is still evolving, with new knowledge to suggest that visual maps of the world deep within the brain have corresponding audio maps (Blesser 2001, p. 887). The second reason for privileging description and discussion of the aural over comparison with the visual has been to focus on sound and sound making. The projects of this PhD were produced in a research and teaching environment where visual representations are the primary modes of design communication, and where an emphasis is placed on the visual conditions of spaces and objects. This thesis has been motivated by a desire to extensively investigate the practice of a spatial sound designer through aural-centric modes of representation and presentation. I have carried and refined this position into an area I consider to be the expansion of the individual projects discussed so far - the establishment of an electroacoustic studio in a school of architecture and design.

As previously mentioned, my role in establishing this facility forms a critical moment in the transformation of my own practice from artist to that of designer and researcher. At the time of writing, my role in the Studio is to initiate and direct the research, teaching and cultural activities described in this chapter. Before examining the Studios as a new place for auditory spatial design, I will first advance a critique on the qualitative need for such places, before describing research themes, physical features, and core teaching, cultural and research activities of the Studios.

6.1 The electroacoustic studio in a school of spatial studies

Redefining the role of electroacoustic studios

There are compelling arguments against the need for experimental institutional sound studios to exist today. From the 1950s, into the early 1990s, computer and electronic music studios were necessary to aggregate expensive specialist equipment for a relatively small number of expert users. A consequence of that which is popularly referred to as the "democratisation of technology" means individuals can now afford the resources needed for digital audio research and production, such as sophisticated software, computers with fast processor speeds and larger quantities of storage media. Net-based resources support individuals to disseminate their creative output and access a wide range of technical information. Studios were once the primary custodians of the technical information that is now more readily, although not exclusively, available in books, magazines, on-line forums, blogs and support sites, or discussion lists. While the positive and negative merits of this situation remain debatable, it challenges a response from institutional studios to re-invent their role as cruicbles of learning, research and cultural production.

In establishing the SIAL Sound Studios, I believed it was critical to clearly articulate an alternative to historical and current practice. Electroacoustic music studios on the scale of SIAL's are typically based in music schools, where research and production tends to focus on sound synthesis and technology development, music perception, performance and composition. The positioning of the Studios within SIAL, and a School of Architecture and Design enables us to investigate auditory spatial experience within a broader cultural and social context of the built environment and more specifically, alongside other environmental disciplines and emerging design practices.

An electroacoustic music studio in a school of architecture and design

The SIAL Sound Studios form part of the Spatial Information Architecture Laboratory (SIAL), a "facility for innovation in transdisciplinary design research and education. It embraces a broad range of investigative modes, involving both highly speculative and industry-linked projects. SIAL is concerned with the integration of technical, theoretical and social concerns as part of its innovation agenda."[116]

The Studios were officially opened in December of 2004[118], following a three-year development period and a series of start-up projects. Teaching and research is predominately conducted by project, with an emphasis on production and making as opposed to measurement

116 From the main SIAL website at http://www.sial.rmit.edu.au/About/Overview.php>, viewed July 3, 2007.

118 The opening event was the first Spectrum concert series.

and analysis of numerical data. Software platforms support processes such as auralisation[118], sound synthesis and processing, spatial audio mixing and mastering, and music production. Other equipment is available for studio and field-based recording in stereo, array and ambisonic formats.

Central to all activities in the Studios is a privileging of sound as its own best representation. In all other parts of the School of Architecture and Design, the primary mode of representation is visual, whereas a central aim of the Studios is to make design audible. At the undergraduate level, this is pursued by an experiential mode of learning and further exemplified in the *CitySounds* research project discussed previously. The operational paradigm for the Studios is one whereby projects may utilise six general development, or production modes and associated spaces. While project modes may be interchanged depending on development and evolution of ideas, the need to maintain efficient use of the Studio facilities implied avoiding certain scenarios, for example; having the the main studio booked for Max/MSP development that could be undertaken on a desktop system or in the Small Studio (see Figure 26, page 245 for a floor plan of the Studios).

6.2 The ensemble of elements

I think of the Studios not as a facility with activity, but as an interconnected community based in a facility, identifiable through an ensemble of elements. The following examination of those elements is strongly reminiscent of Etienne Wenger's fruitful concept of a community of practice[119], where the collective domain in the Studios is auditory spatial awareness, the community engages in shared activities such as the concepts and projects discussed below, and the practice is advanced through a shared repertoire of electroacoustic resources and techniques.

Research themes & projects

Three broad themes of practice-led research have emerged for the Studios:

- Spatial Sound Performance and Installations
- Urban Soundscape Research and Design
- Acoustic Design

The main program elements through which these themes are activated are contract and grant-based research, Post Graduate research, undergraduate design studios and electives, publishing and public events. It is important that the domains be general and small in number. Currently, both the available staffing numbers and physical space are limited. I also considered

118 Auralisation is a process for predicting the acoustic performance of a yet-to-be constructed space. Through digital signal processing, source-receiver relationships can be created and aurally demonstrated, displaying reasonably accurate acoustic prediction.
119 See <http://www.ewenger.com/theory/communities_of_practice_intro.htm>, viewed July 3, 2007.

that it was better for the long-term viability of the Studios to focus on founding and developing a limited number of activities that have porous boundaries and rich interconnections rather than creating solidly demarcated fields of practice, which could lead to vested cliques being formed in the future. To that end, the following table of themes and activities within themes displays significant overlaps between the cells.

		Activities within themes						
		Design Studios	**Electives**	**Post-Graduate research topics**	**Funded research**	**Contract research**	**Staff research**	**Publishing & events**
Research Themes	**Spatial Sound Performances and Installations**	Symph-onic Home	SSCAD	Interfaces for Spatial Sound	*Spatialised Ensemble*	Auditory City concerts	Matrix system for concerts	Spectrum concert Series and papers
	Urban Soundscape Research & Design	Memory Games Future Sound of Cities	Soundscape Studies	Modelling sounds for Japanese Gardens	*Teimu* and *Urban Soundscape Group*	CitySounds 1.0 and & case studies of 5 soundscape systems.	*Canopies* installation	Installations, industry symposia and papers
	Acoustic Design	Museum of Sound	Bouncing off the Walls	Theoretical acoustic and spatial models for architectural environments	*Teimu*	CitySounds 2.0		Papers

Table 34: SIAL Sound Studios *research themes.*

Practice-led research themes and associated activities through which the themes are made present in the program of the Studios. Further brief descriptions of projects presented in this or other chapters appear in Appendix 4.

While the undergraduate activities are concerned with the teaching and learning of designers about to enter professional practice the research streams have two roles. The first is to investigate ways that a greater auditory awareness can be engendered in design-based professions and also in the broader community. The second agendum is to undertake projects with a speculative focus and a longer time horizon of at least five years purposed for the useful outputs that might be achieved. The Australian Research Council[120] (ARC) funded project *Teimu*

120 The Australian Research Council (ARC) "is a statutory authority within the Australian Government's Innovation, Industry, Science and Research (IISR) Portfolio. Its mission is to advance Australia's research excellence to be globally competitive and deliver benefits to the community". From <http://www.arc.gov.au>, viewed January 18, 2008.

(Garden of Dreams): aural and aesthetic attributes of Japanese gardens as models for spatial environments is an example of this long-term approach. The team on this project includes Chief Investigators who are architects (Dr Peter Downton, Dr Gregory Missingham and Alex Selenitsch), a performer (Dr Michael Fowler, Post-Doctoral fellow) and myself as composer-sound designer and Chief Investigator.

The following quote is from the original project description:

> Traditional Japanese garden design has greatly influenced both 20C [sic] Western landscape designers and composers of Western art music. By investigating the aural and aesthetic attributes of five renowned Japanese gardens, RMIT and University of Melbourne researchers will seek out spatial sound designs that could enhance sound quality in urban environments and provide a pioneering approach to architectural modeling and the built environment. This project has long-term cross-disciplinary implications. The results and methods contained in this project may assist in innovative sound design for new media applications, better listening environments in urban areas, unique approaches for data modeling, and a catalyst for future design strategies.[121]

Personnel and expertise

The presence of equipment, software and specialist facilities, would on their own merits, be unlikely to bring about a change in thinking in design professions with respect to auditory spatial awareness and the importance of sound. Composers and sound designers trained with critical listening and technical abilities to 'think' in sound are in a primary position to argue for, collaborate and champion the importance of sound and listening. Their expertise in using specialist sound equipment; teaching and researching with creative ends in mind, that is; to consider sound more in Truax's communication model than as an energy model is a differentiating factor for locating a sound studio, and not an acoustics department in a school of spatial studies. While Studio personnel have a collegial responsibility to support the work of other design practices, they must also be involved in the development of practices that are 'sound-only'. From experience, my reasoning for is that while collaboration with other practitioners and combining sound with visual or performance media is important, it is through composition, performance and installation projects that one most extends one's practice. This extension not only compels professional development to occur, but new knowledge and approaches to spatial sound might emerge, away from the constraints of collaborative endeavours.

The Facility

The six main research and production workspaces and scenarios are:

121 From http://sound.sial.rmit.edu.au/Projects.php>, viewed July 14, 2007.

a) *Desktop systems* – early development and experiments in software and/or small hardware configuration using headphone or stereo monitoring. Work at this level might include Max/MSP, sound file processing and editing or model-building for auralisation.

b) *Small studio* – interim stage where multi-channel sound output is needed, but a critical listening environment is not required, for early to mid-stage composition, editing, track arrangement or sound processing development on a fourchannel system (see Image 41).

c) *The Pod* – an eight - sixteen channel spatial sound studio with re-configurable speaker system, around a central production and listening location. This space is sound proofed and close to anechoic. Work modes include individual research and production, final mastering, recording for the purposes of auralisation, sound design for gaming environments, spatial sound composition, and small group presentations (see Image 42, Image 43 and Image 47).

d) *n-space* – a space for collaborative work, rehearsals, presentations and formal lectures equipped with a re-configurable eight - twelve channel system, computer, data projector, large screen and large LCD screens (see Image 44).

e) *Sound diffusion system* – presentation on a concert system of around thirty loudspeakers (see Image 48 to Image 54). While most of the system is in storage between events, a small version is used in n-space.

f) *Field and studio recording* – using stereo, array or ambisonic recording technologies (see Image 45).

Image 41: SIAL Sound Studios: *The Small Studio*

This room is a four-channel studio used mainly by undergraduate students preparing spatial sound mixes for n-space. See Image 44 below.

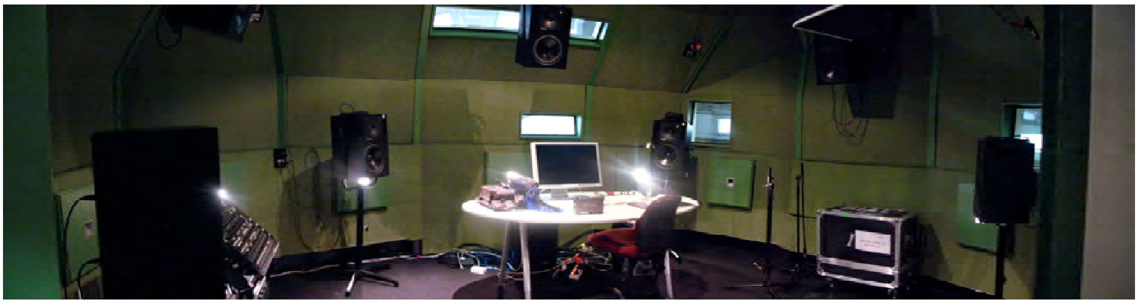


Image 42: SIAL Sound Studios *interior view of* The Pod

The Pod *studio in work mode. The centrally located desk, railing mounted and floor standing speakers can be easily moved. The oval shape of the room is intended to mimic the circumambient field of listening better than a traditional box-like studio. The windows on the far side of* The Pod *look directly into* n-space *and onto external windows also.* The Pod *in this configuration has 8 Genelec 1032A loudspeakers.*

Image 43: SIAL Sound Studios *exterior view of* The Pod

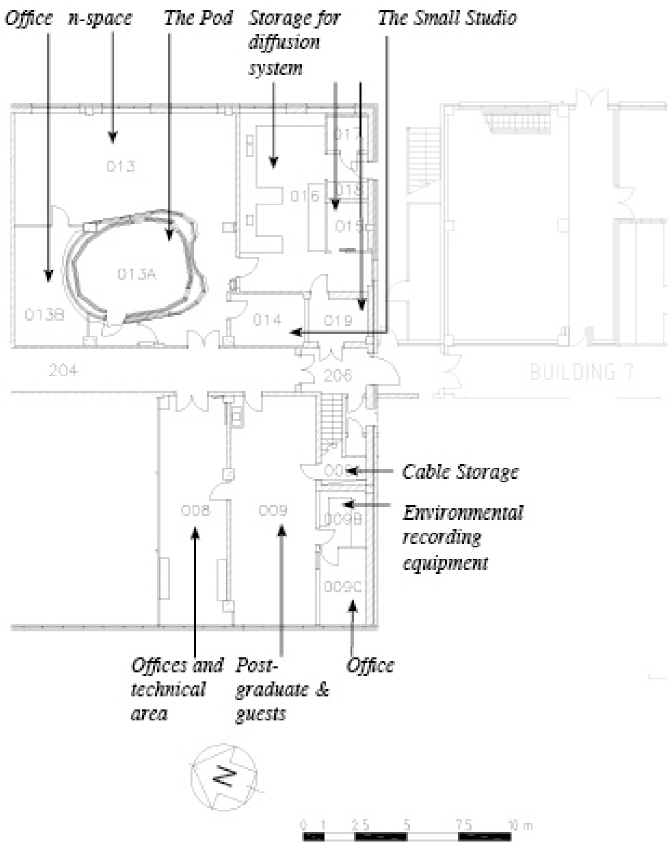
The architect for The Pod *was Paul Morgan whose interpretation of the brief for 'a pod' drew on Stanley Kubrik's film* 2001: A Space Odyssey (1968). *The internal gap between the two layers of the structure can easily be seen through the windows. This image was taken soon after completion and just prior to equipment being installed in the facility.*

Image 44: SIAL Sound Studios n-space

Image of n-space *with small diffusion set-up for rehearsal. In this configuration,* n-space *is suitable for a single user, small class or small rehearsal.* The Pod *can be seen on the right. The room has some sound absorption installed along the ceiling mounted air-conditioning and the walls.*

Image 45: SIAL Sound Studios *field and studio recording*

Studio and environmental recording equipment available in the Studios. This image includes ambisonic microphones and decoder units, a dummy head binaural recorder, stereo and mono microphones, and 2 and 4 channel hard-disk recorders. A sound pressure level metre appears at bottom of image. All microphones have fixed and mobile stands and shields for wind protection during external recording.



Start of project → ***End of project***

Work mode	Early development work Recording	Interim or middle stage work Rehearsals Lectures	Final production work Mastering Critical listening	Concerts
Technical requirements	Small stereo system headphones	Four channel studio	Eight-Sixteen channel studio	The diffusion system
	Stereo, ambisonic, array recording devices	n-space small diffusion system		
Locations	Offices and Postgraduate area	n-space	The Pod	Concert spaces
	Recordings in The Pod or on location	The small studio		

Figure 26: SIAL Sound Studios *floor plan and indicative project flow*

The footprint of the Studios is not large, measuring 285 sq metres in total. An indicative workflow for project-based research is shown against technical requirements and location.

The physical studios and associated listening conditions support collaboration and learning. During the intensive learning period of an undergraduate course, critical listening skills are best developed if sound materials are presented in a way that can demonstrate subtle qualitative differences. While *The Pod* studio is the isolated space for critical listening and production, other spaces in the facility are also acoustically treated to limit impacts of air-conditioner noise and sound reflections. Further, all spaces have, or can support the use of spatial sound systems for most learning and research activities. Access to this type of configuration in all spaces is one aspect that can serve to differentiate a home studio from an institutional facility, although spatial sound systems in project studios are achievable at relatively low cost. Other attractive conditions cited by Post Graduate candidates include access to a quality mastering environment, opportunity to utilise the diffusion system, critical feedback from staff and colleagues, collaboration with other disciplines, and equipment for preparing and presenting larger projects.

The Pod

Providing students and staff with critical listening conditions was paramount in establishing the Studios and program. If a sustained thesis on changing acoustic conditions were to be advanced as an agendum at the Studios, then the process for doing so requires a space where detailed listening and sophisticated sound processing can be undertaken. There is a technical requirement in processes such as auralisation and mastering for pristine acoustic conditions. I would extend this also to include composition and sound synthesis. Without the blank canvas afforded by extreme quiet, effects such as masking, but also of interference with projective listening are likely to occur, and be disruptive to the sound designer's auditory imagination. All potential noise sources, such as computers are located outside of *The Pod*, which has a double skin and sits on neoprene shock mounts to reduce low frequency structure-borne noise. (See Image 47)

The Pod is the facility's main studio. I often describe *The Pod* as a 'vessel', invoking two senses of the word. The first is vessel as 'container', and relates to the metaphoric process of the designer pouring their auditory imagination into a single space. The room becomes an extension of their design process, the equivalent of the screen in the dark room for the film-maker, or animator. The other use is vessel as 'craft' whereby the *The Pod* is the vehicle for traversing sonic landscapes. Sound designers talk about 'immersiveness' in a sound field and 'listening' as a journey through resonant matter. *The Pod* chamber has near anechoic conditions, necessary for the detailed listening required in production, but also to provide a resource that prove difficult and costly for individual researchers or students to self-fund, therefore making it an attractive proposition for others to work in the facility. The low noise floor is also maintained by situating all computers outside the room, and the provision of 'slow-flow' air-conditioning, which is piped between the double skin (see Image 46) of the room and emanates from a small gap between the floor and the internal wall. The deep green of the interior is one I selected from working in many different light levels and interior wall finishes of various studios. I find white too spatially flat, and black too depressing. Green is suggestive of depth, as one might find in natural habitats where the acoustic horizon is expansive, or ocean water where the limits of firm terrain are hidden.

Image 46: The Pod *view into double skin*

This image shows the inner and outer skin of The Pod*, exposed to reveal construction techniques for architecture and design students. The view is across to the small studio with its door open.*

Image 47: The Pod *during construction*

Neoprene springs for floating floor. Image taken during construction of The Pod *in 2004.* n-space *is immediately to the right of this image.*

The diffusion system

The concert has unique features over other types of sound-based modes of presentation such as CD, radio or installation. It is a group listening environment, maintaining a social dimension to the experience. There are conventions that ensure listening attention can be maintained. There is potential for the creative and/or performing artist to engage with an audience. The diffusion system is employed to create unique concert experiences for audiences, based around spatial sound works. Elsewhere, I have discussed the role of the studio as creating a cultural presence for auditory arts and ideas.

In the teaching activities of the Studios, 20th Century and contemporary music are used as models for spatial auditory design, for ideas about time and temporal organisation, approaches to notation and the diagramming of ideas, and to explore the aural experience of the sounding world through instrumental and electroacoustic music composition. In the lecture setting, stereo audio recordings might suffice for general understanding of a musical or sound-based composition, but a performance brings the music to its intended moment of reception: a concert setting with an insistence on attention and listening.

Through intersecting research endeavours, three sites of practice are emerging for the Studios: spatial sound concerts, urban acoustic design interventions, and large-scale electroacoustic installations. Many practices of art and design have an enduring quality, ensured by the stability of their materials and construction. Sound-based practices are momentary, needing specific conditions to ensure they have a continuing cultural presence in the life of the city. But thinking further, the role of the concert is seen for its potential as catalyst for a discourse on spatial sound design, the aurality of contemporary culture, and the qualities of spatial auditory experience.

Teaching & auditory learning in a school of architecture and design

There is a distinguishable difference between the educational aims of schools of music and schools of architecture. Having attended, and taught in both categories, I can qualifythe following observation about production of work. In a school of architecture and design making is paramount. It is discussed, explained, reflected upon, debated to show how the physical conditions and properties of making are critical to the design outcomes, and generally held to be a topic of research to better understand design as a creative pursuit and position its purpose in the contemporary world. In music schools, musicians are taught to perform music, not to make music.[122] The realisation of the score in performance is the singular focus of study, not the broader agenda as pursued in schools of architecture and design. Similarly, in computer music an emphasis is generally placed on the technical aspects of production and less on issues of

122 I would argue that the aim of a musical education should be learning how to make concerts, which would encompass not just the rehearsal and playing of repertoire, but making the responsibility of the musician extend to all aspects of the listening moment for the audience. This would encompass how the concert is marketed, to the type and location of venue, seating, spatial listening relationships, the quality and quantity of information in the program, whether the works are verbally introduced or not.

making. I would argue that the purpose of a musical education should be focussed on a broader agenda of making, which would encompass not just the rehearsal and playing of repertoire, but extend to the social functions of music, programming and performing for a plethora of acoustic conditions and spaces, collaboration between musicians and other disciplines, project and concert management, dissemination of ideas through all types of media, building relationships with audiences and communities, and the perspective of music as just one manifestation of human auditory spatial experience. The format of the design studio as taught at RMIT University is such that broad agendas may be addressed in a comprehensive way.

At present, two teaching formats are offered in the SIAL Sound Studios: the design studio, and the elective. Since its opening, three sound-based design studios have been taught; *MemoryGames, Museum of Sound* and *The Future Sound of Cities*. A design studio[123] in architectural education is a mode of teaching by 'the project'. In most cases, the project is expressed through a brief, which might propose an actual site, a theoretical proposition, or a general or specific issue requiring design response and resolution. Design studios run parallel to single subjects and electives, where historical, theoretical or technical subjects are taught. A teaching studio is a semester long subject – approximately thirteen weeks – involving between three to -five contact hours per week, and requiring another six totwelve hours of work by the students each week. The outcome from a design studio might include substantial design drawings, or digital representations, built scale models, and in some instances, fully constructed designs. A design studio is a mode of learning that is simultaneously applied and theoretical, combined with learning experiences to prepare students for professional practice. Traditionally, these outcomes have not contained any consideration of sound or aural realisation of the project, which is a situation we are actively addressing.

To develop awareness in design students of the role played by listening in spatial experience, practical activities to enhance their production, analytical and conceptual skills relating to sound are simultaneously applied. Listening exercises are conducted using parts of the sound diffusion system, selected sites in and around the City, and other media. This experiential mode of learning is the ground upon which students' further expand their knowledge of auditory experience, and the acoustic environment before branching into disciplines such as acoustics, psychoacoustics and electroacoustics. In the initial learning stages, the multi-disciplinary approach of acoustic ecology, and its listener-centred model is ideal for educating architects and designers whose practice will substantially affect the future acoustic conditions of the built environment.

Currently two electives are offered from the Studios across the University – *Soundscape Studies*, and *Spatial Sound Composition and Diffusion*. These electives, and three more in development at the time of writing, are pathways through which different disciplines access the Studios. For example, an engineering student may be technically proficient, but in need of a cultural context to inform their work. Similarly, a design student may be highly skilled at visual spatial representation, but needs to learn and explore more about spatial sound design.

123 'Design studio' as used here means a mode of teaching, not a physical space.

A strong emphasis is placed on developing the students' own aural abilities in learning. In using games engines for the design of soundscapes, the intended aim is to evince a mode of learning that is experiential. This listener-centred approach contrasts to traditional sound courses in architecture and design programmes that commence with an energy model from architectural acoustics. The basis of such courses is traditionally quantifiable measurement, and an avoidance of contextual factors and listening (apart from psychoacoustic concerns) often considered as too subjective. While architecture students are visually astute, their listening skills and general awareness of the acoustic environment is often under-developed. However, their ability to imagine spaces in three dimensions, and consider the motion of an observer through space is an important skill that can be harnessed when composing a soundscape in virtual space. From a listener's perspective, an actual acoustic environment is circumambient. Providing a pedagogical resource that can partly replicate this listener-environment relationship is essential to demonstrating the immersive qualities of the soundscape. The games environment we use has been enabled with multiple audio outputs, connected to loudspeakers placed in front of, and behind a listener sitting in front of a screen. This set-up uses four channels of the 5.1 format now widely available in inexpensive sound cards, allowing students to create circumambient sound fields to accompanying their 3D visual model of a space. Compared to other readily available sound playback formats such as two-channel tape or CD, a surround sound system has proven essential to create an experiential listening context.

The pedagogical objective is for students to understand that the built environment resonates with the sounds of human presence, natural events and technological interventions, and that architectural form and design decisions shape the sound of an acoustic environment in significant ways. Within the virtual environment, students assume the role of acoustic designer or soundscape artist, a position they might one day translate to the built environment, enacting Westerkamp's presentation of the role of a soundscape designer:

> Beyond fighting sound pollution, the task of sound ecologists is to design healthy and attractive sonic environments, sonic places. Continual sensitization of the ear, creative town planning, legislative action (noise abatement regulations), the design of acoustic parks and playgrounds, and the innovative preservation of worthwhile sounds of past and present may be among the means to achieve such ends. This turning of the negative spectre of a polluted sound world into a vision where the sonic environment becomes a place for renewal and creativity has been the genius of the World Soundscape Project (Westerkamp 1991, para. 8).

To date, the experiential foundation of acoustic ecology has been an important basis for virtual soundscape design exercises at the undergraduate level. I view this as essential preparation for students' later investigations into computational acoustic modelling, materials research or aesthetic speculations on the aural experience of architecture within built and digital environments.

My work as a curator between 1996 - 2000 has been reactivated in this element of the Studio's activities, albeit with the added dimension of having to encompass research and teaching themes in concert programs. In the teaching activities of the Studios, 20th Century and contemporary music are used as models for auditory spatial design, for ideas about time and temporal organisation, approaches to notation and the diagram of ideas, and to explore the aural experience of the sounding world through instrumental and electroacoustic music composition. In the lecture setting, stereo audio recordings might suffice for general understanding of a musical or sound-based composition, but a performance brings the music to its intended moment of reception: a concert setting with an insistence on attention and listening. The evolving concert program of the Studios is equivalent to the visual exhibition of other parts of the School, and is seen for its potential as catalyst for a discourse on spatial sound design, the aurality of contemporary culture and the qualities of spatial auditory experience. To that end, a primary role of the concerts in the life of the studios is to make the spatial sound works present and as enduring as possible, in the cultural life of the University and the City proper.

During the start-up phase (2002 - 04), the development team supported two international conferences[124] and presented the work of over thirty composers. Since the Studios' official opening, the *Spectrum* series has been established as the public concert series based on composition and performance work of staff, Post Graduates, associates and guests. To date, three *Spectrum* events have been held: *Spectrum 01* (Horti Hall, 3 - 4 December 2004), *Spectrum 02* (BMW Edge, 2 - 4 May 2006) and *Spectrum 03* (Arts House, North Melbourne, 24 - 26 May 2007). Programs for Spectrum 02 and and 03 included new works composed in the Studios, along with Australian premieres of Stockhausen's *Klavierstucke XVI*, and solo and chamber works from *Licht.*

In July of 2006, a pilot project concert to test another programming approach was held in RMIT's Storey Hall. The format of the event included a tenminute talk on the works and recent research related to the pieces, followed by a fiftyminute concert presentation. The repertoire was selected for its relationship to a design studio and research project then being undertaken in the Studios. The *Fermata* design studio was investigating notions of the pause in the City, and the provision of sites-of-respite, expressed through works where silence is a primary structural device of a composition. Works influenced by Japanese garden design, related to the *Teimu* project discussed above, formed the second programming theme.[125] The one-hour format formed the basis for a series of lunchtime concerts in late 2007, exploring auditory spatial awareness and the urban environment, involving a series of performances through the CBD of Melbourne, based on particular sonic effects created through the built environment.

124 Australian Computer Music Conference, 6-8 July, 2002 hosted in conjunction with the Victorian College of the Arts, and the Australian Forum for Acoustic Ecology Conference 19-23 March 2003, see <http://sound.sial.rmit.edu.au/Events.php>, viewed February 25, 2007.
125 The full program was *Landscape* (1971) by Peter Sculthorpe (b.1929), *Ryoanji* (1983) by John Cage (1912-92), *Six Japanese Gardens* (1995) by Kaija Saariaho (b. 1952), and *4′33″* (1952) by John Cage.

A software development project to support efficient management of concerts was undertaken in parallel to the concerts. Following the first two *Spectrum* events, I was able to prepare a brief based on necessary technological platforms and known production pressures for producing multi-format, multi-composer concerts. The system design is based in the Max/MSP environment and currently has the following modules:

- an input module, scaleable from 1 – 32 inputs in any combination of line or soundfile playback
- a matrix module that allows unique combinations of processing chains or output types to be configured and uniquely named
- an output module
- a mapping module for configuring and scaling MIDI[126] controllers of system parameters.

Importantly, the system is very stable, not CPU intensive, and with local and global recall of all settings. This means that during a sound-check, the production crew can configure the system input types, matrixing settings and output settings on a piece-by-piece basis, in the knowledge that stepping between one piece and the next is not an issue. The system does not use proprietary hardware, which reduces cost and has meant we no longer use a mixer in the main diffusion system. In several ways, the system is developed to make the technical interface to the spatial sound diffusion system as transparent as possible. Two examples of this are bump-in time and artist management. During 'bump-in', once a physical speaker cable has been connected to an output channel and identified, it is not touched again. If for some reason, a speaker signal is not appearing from an intended output channel, then changes are made in software, and the source output channel renamed. This avoids the time intensive exercises of following incorrectly patched leads and loudspeakers. Secondly, artists can bring in mono files up to 32 in number, input them into one folder, and have them appear in any location of the 32 inputs. These input files can then be patched and duplicated to any of the system loudspeakers. Extensions to the base system are in development and include mapping of virtual sources, expansions of processing chains with spatial output and 3D panning.[127] However, the main purpose of this development is to reduce the time and possibility of technical errors, and support flexible concert set-ups through which ever- changing curatorial approaches to concert-making can be explored.

126 MIDI is Musical Instrument Digital Interface, an industry protocol for communicating between digital musical hardware and software devices.
127 Programming on this project has been undertaken by the Author with substantial components developed by Jeffrey Hannam, Production Manager of the SIAL Sound Studios.

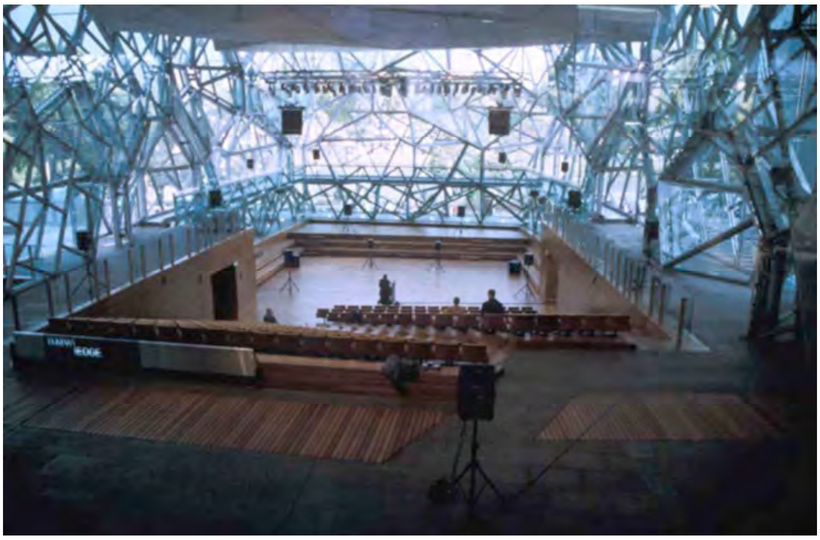


Image 48: Concert set-up BMW Edge

The diffusion system during a sound check for concert at BMW Edge, Federation Square, Melbourne as part of the 2003 Australian Forum for Acoustic Ecology Conference.

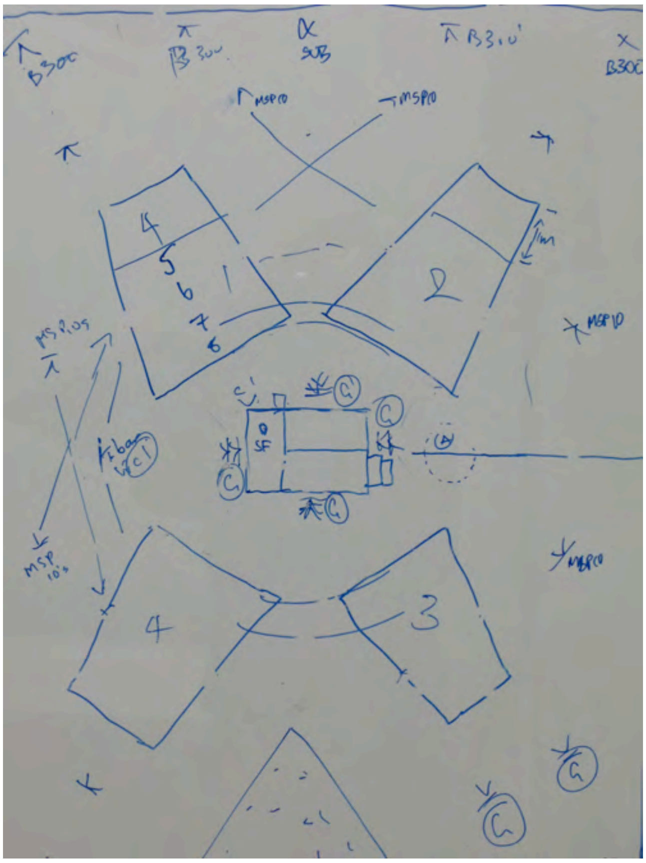


Image 49: Spectrum 01 *whiteboard sketch of diffusion set-up developed for Horti Hall*

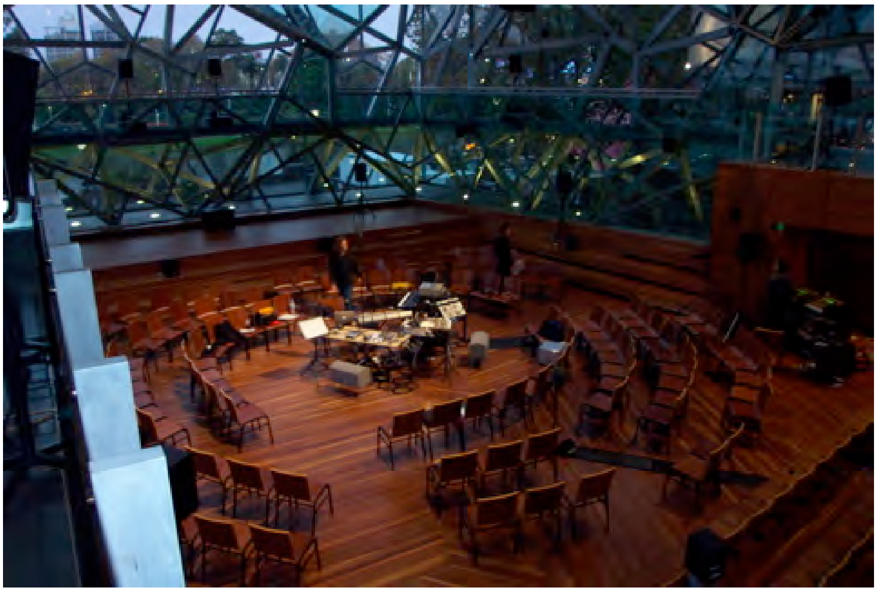


Image 50: Spectrum 02 *circular seating arrangement*

Seating arrangement based on Pole *diffusion requirements*

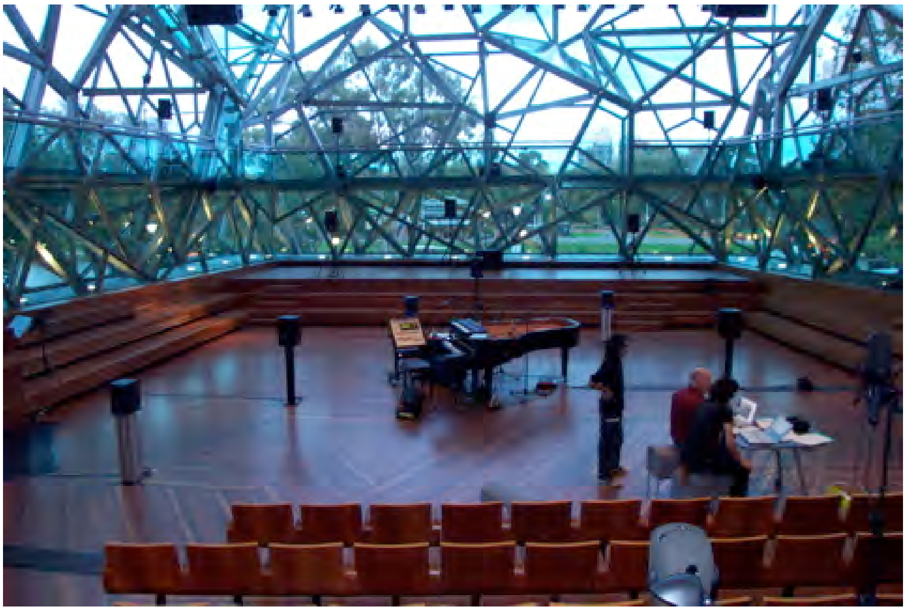


Image 51: Spectrum 02 *final sound checks*

Image taken on second night with staging and diffusion based on Klavierstucke XVI.

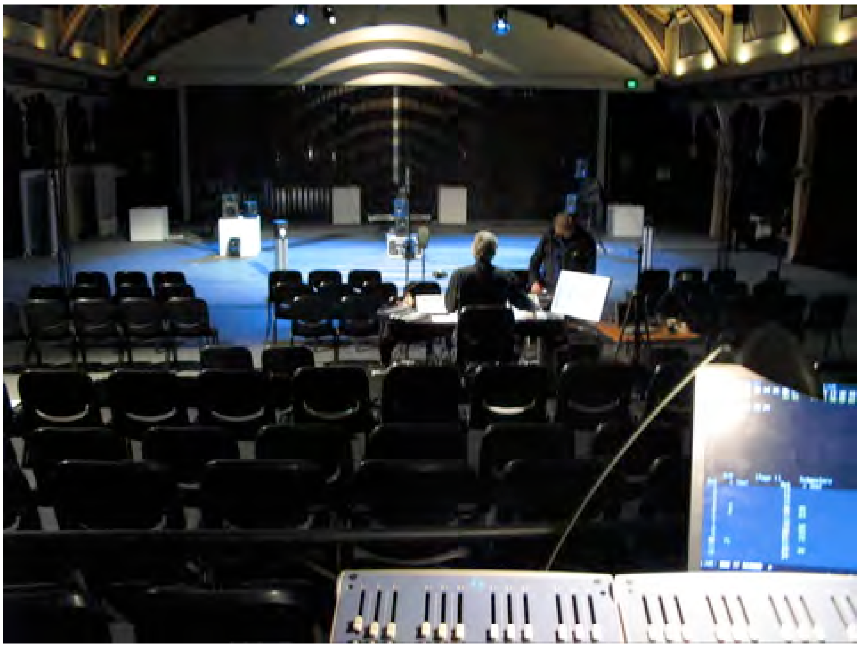


Image 52: Spectrum 03 *final soundcheck for* Auditory Cities *concert*

Image 53: Spectrum 03 *central mixing control*

The four MIDI control surfaces link to a Max/MSP environment seen on computer screen on right. In the current 'base' system, each speaker is mapped to a single fader, however the software controls allow individual faders to control grouped loudspeakers.

Image 54: Spectrum 03 *concert setting*

Stage area with diffusion system. This image was taken just prior to Concert 3, an all diffusion concert. The central mixing console can be seen in the middle of the image. Composite picture courtesy of Peter Holmes.

Post Graduate research

The current Post Graduate cohort originates from five home disciplines: composition, performance, architecture, acoustics and computer science. The Studios now occupy an independent stream in the School's Graduate Research Conference, a threeday event held twice a year where Post Graduates present work in progress, or make their final examination presentations. Cohort research projects range from architectural designs, spatial electroacoustic composition and performance, environmental sound synthesis for virtual applications and interaction design. The topics of individual Post Graduate candidates map into the three research themes presented above to varying degrees. In part, this has been determined as the facility, teaching and research streams developed in parallel while also seeing opportunities arise to curate themes through candidates' own interests and aspirations.

Conclusion

Advances and availability of technologies for spatial sound production have contested the need and role of electroacoustic studios. Yet far from viewing these challenges as a reason for their demise, I presented concepts and physical elements of the SIAL Sound Studios as a viable model by which electroacoustic practices might emerge as a new spatial design discipline. It is the combination of elements that is significant. These encompass a set of distinct research themes, a facility for the production, presentation and preservation of auditory spatial artefacts, a teaching program through which long-term changes in design thinking can be enacted, and modes of engaging with other academic and professional disciplines, as well as the general community. The electroacoustic studio as a community of practice is essential to its role in nurturing the final critical element – the expertise of individual practitioners, whose own careers might offer solutions to the proposition that 'good design is intelligence made audible'.

7.0 Conclusions and final evaluations

> *The milieu and the standing patterns of behaviour, through the synomorphy that weds them, form the final environmental unit. The designer does not design the environmental unit, only its milieu. His influence is limited to that which his milieu, through synomorphy, contributes to the final standing-patterns-of-behaviour-and-milieu unit (Gump 1971, p. 132).*

In his 1971 article in *Landscape Architecture*, Gump describes how behaviour-setting theory may be useful for designers. After first presenting the main components of the theory, he posits that it, "may be useful in delineating the place of [designers'] efforts in relation to the human environments which actually become established. The designer develops milieu..." (Gump 1971, p. 132) Gump goes on to say that the degree of influence the designer has on the final standing-pattern-of-behaviour-and-milieu-unit, is limited by the contribution made by the milieu he (or she) designs. The designer first asks, "What goes on here?" (Gump 1971, p. 134).

Since entering in the intensely reflective world of design research at the School of Architecture and Design at RMIT University, I have sought ways of investigating and studying the auditory experience of space. This is not to suggest that the project of disciplines such as acoustics or psychoacoustics to comprehend auditory perception and acoustic space, have not been, or are not, useful. But the history of acoustics and architecture has been problematic, and furthermore, my own spatial practice through composition and sound design is, of course, neither as an architect, nor as an acoustician, but that of practitioner intently concerned with the aural conditions of the contemporary world. This intermediary position, between disciplines has meant I can draw from neighbouring fields yet propose alternative ways of investigating and presenting knowledge about auditory spatial experience.

Sites of practice & audience: the auditory quality of milieux

A spatial sound designer establishes an auditory milieu that provokes aural attention – listening. To briefly invoke the information theory distinctions of signal and noise, the presence of sound design is to enhance or increase the signal, the auditory information for the listener. The *CitySounds* question on when something is a sound or noise demonstrates that respondents are aware of context-influencing factors. It is not purely about the measurable or audio recordable components of an acoustic environment. The listener's answer to "What goes on here?" is as much a determinant as the measurable audio signal itself.

Threaded through these projects is a central concern for the moment of auditory reception, wherever, and whenever that might occur. Cultural audiences in different settings have different modes of auditory reception. A concert is a distinctly different setting to an interactive installation; a site-of-respite in an urban setting differs froma gallery installation, a multi-channel soundscape system is different to a concert. Yet is the potential significance of these milieux is not their inherent differences, but the possible links between them. One future direction for my work is toward further investigation into the circuits of auditory information that could operate between milieux in an urban environment. To that end, I now consider the projects as components of a meta-project, as models for the auditory-based practice of a designer in urban milieux. As I gradually decoupled my focus on musical performance and the concert hall, the spectrum of potential sites of practice expanded. The process of re-conceiving my practice, of finding its anchor points also meant the type of audience for my work changed. From the *Canopies* project onwards, I was interested in ways the rich auditory landscapes of electroacoustic music and spatial sound design could be made present in the everyday spaces of life.

Where projects did take place in cultural spaces, my intentions were to invite the audience into alternative auditory spatial schema. I use the word 'schema' in the sense of an organisation of concepts and actions that can be revised by new information about the world. In that sense, I am asking the audience to suspend belief about the way their auditory world operates, and to momentarily consider an alternative proposition. Throughout *SoundSites*, the sighted audience of the visual art gallery is asked to piece together the auditory experience of an unsighted person negotiating physical spaces. The idea of the listener traversing milieux is carried into the *CitySounds* survey, projected into the public domain as the basis for a series of listener-scale conceptions of urban space. In *Ecstasis* and *Symbiosis,* the environment-forming role of the soundscapes in a VR Centre presaged not simply locating a corresponding sound world to the visual, but also the making of a three-dimensional dynamic soundscape capable of transporting the audience into that world. The soundscapes had to appear to emanate from the physical conditions of the 3D environments, and not merely act as an accompaniment, or soundtrack to images projected on a screen. The boundary between the actual and virtual is further dissolved in *Canopies.* While at one level it can be considered as an auditory utopia, by its projection back into an urban setting through the soundscape system, it becomes part of the quotidian auditory experience of listeners on the site. This is opposed to *K,* where the audience is brought into intimate physical contact with a human being in an extreme state of despair, the sounds are clearly associated with a physical condition of torture and harassment, enveloping audience and actors alike in an auditory dystopia.

Collaboration in non-arts contexts and communities

In working further afield from my home discipline, I came into collaborative partnerships and creative relationships beyond those of my initial training and previous experience. These new relationships were sometimes mediated by a brief – particularly, in *CitySounds* and *Ecstasis.* Both were subject to extensive contractual negotiations and arrangements. In other instances, a detailed project description leading to a successfully funded application provided a framework for the project (*SoundSites* and *Canopies).* Collaborative partners included a curator in *SoundSites,* an architect and media artist in *Ecstasis* and *Symbiosis,* a social scientist and programmer in *CitySounds,* architects in *Teimu,* and a theatre director for *K.* As I discussed in the *SoundSites* section, a readily available language to discuss sound and auditory experience is not universally present today. Therefore the ability to accurately describe and define a sound design ahead of time in the case of an application or contract preparation, or project report is necessary. Unlike other design disciplines, or even musical composition, there is no prior representation of a sound project. There is neither score, nor plan as the basis for intra-disciplinary communication, let alone interdisciplinary exchange.

Activist role

After *SoundSites*, I was determined to seek a stronger social and environmental focus to my work. A creative project demands a necessarily singular focus. Having honed one's skills, one is then equipped to apply one's craft and intellectual capacity to other endeavours. When artists are taught to make work, they are also learning problem-solving skills of a particular type, along with personal positions on technical, aesthetic, historical, environmental, legal and ethical issues. The link between *CitySounds* and *Canopies* is through their shared concerns for the auditory qualities of urban spaces. A creative component exists in both, particularly through the creation of each projects' sonic content. But a central aim of both projects was to generate a discourse around spatial sound design and its auditory experience in the city. My interpretation of the activist role is to be a catalyst, to propose, build, test and reflect speculative positions on the acoustic environment, as opposed to experimental composition. This is the position in my own work, at the scale of singular designer. An expanded role for this position is proposed at the end of this chapter.

Creative mediation and minimal intervention

My compositional practice leading to *SoundSites* had been grounded in making transformations of sounds into more complex versions of themselves. My ear was drawn to discovering the potential of a sound to reveal its other qualities through digital signal processing. However, in *SoundSites*, the process of translating the aural experience of unsighted people in physical space into an art-based exhibition for sighted listeners, was also an act of creative mediation. To discover the most precise method of conveying the experience of unsighted participants called for an approach of minimum intervention, which I interpreted in two inter-linked ways. The first concerned the selection of sites, or events. Before recording, I would visit a site as often as possible without recording equipment. Visiting solely with the intention of assessing a site for later recording implied I had focussed on the site for its potential. This amounted to assessing the soundscape with 'recording ears' on. The second method was to make recordings with the intention of applying only minimal edits afterwards. The first constraint can be seen as rehearsal: finding a path or feature in an environment that is likely to yield material conveying an aspect of the unsighted soundscape experience. For example, the section in *SoundSites* entitled *'Transitions'* arose from a comment about the difference between entering new and older building types in the city noted by an unsighted participant. In the newer buildings, the internal soundscape is much like the city itself. Sound bounces off highly reflective surfaces, and a generally disorientating cacophony is presented to the listener. In older buildings, the difference between the external and interior environment is more pronounced. As an older building may lack air-conditioning systems and support more complex geometry than flat hard walls, it is likely to have a diffuse sound field. By assessing many sites in the Melbourne CBD, I found three different transitions located on the same street, on the same city block. This meant that the start of each transition could be kept consistent, an important factor to the Project as I was trying to communicate the difference in the sound qualities of the interior spaces, not the exterior conditions listeners were leaving behind.

Research and curatorial roles

Over the course of this PhD study, my professional work converged into a directorial role. As an individual artist, one's primary focus is on the production of works as platforms for the expression of ideas. In expanding my role into the direction of an electroacoustic studio, new elements, or platforms come into play. Where an artistic work, or project is a singular expression of an idea, a centre must support multiple, yet coherent endeavours. My approach has been to create an environment in which multiple research projects may be sustained, contributing to a coherent narrative, or focus. This environment is comprised of integrated elements: the physical facility, along with a linked programme of teaching, research, publications and events. In providing such an environment for others, I have found the need to question and develop a clearer self-awareness of my own design practice, which becomes not an end in itself, but generative of ideas and approaches that might be generalised.

The establishment of the SIAL Sound Studios unfolded in parallel to the projects of this PhD and encapsulate much of the conceptual work underpinning my practice as a designer and researcher. The elements of transfer cover technological items, facility design, project focus (for example, production, not analysis) and collaboration. My own work through this time has been a catalyst, or perhaps more accurately, a crucible in which to experiment and develop ideas to a robust form suitable for an organisational entity, as opposed to an individual endeavour. Electroacoustic practices functioning as a design discipline have two roles to play. The first is the invention of, or propositions for, new spatial schemes primarily experienced through the ear. The other function is to make enduring, the ephemeral auditory artefacts (compositions, performances, installations, sound designs in digital media) of our acoustic environment. Where the auditory imagination of the sound designer brings the first role into existence, the function of the electroacoustic sound studio, is to propagate those works and ideas to other design disciplines, and to the broader community. What might be the end point where these two converging endeavours meet? I suggest it is the auditory city. A congruence of sites, events, education resources and information through which an individual composes an auditory navigational strategy, a composition revealing the auditory identity of a city, not as a series of disconnected moments, but a mellifluous series of interconnected auditory milieux.

Future directions

While the title and abstract of this thesis initially suggests that the transformation in my practice was between two discrete conditions, my own interpretation is that I have merged the streams into a singular practice. Composition demands of composers an internally consistent creative process. A composer's work need not refer to anything outside of itself, but must display a closed, yet coherent voice, or sound world. Just as designers and architects of objects, spaces and buildings must address a plethora of issues, legislation, culture and philosophies, spatial sound design is differentiated from composition where the project is similarly focused on a wider network of concerns than a singular work for concert performance. The practice of auditory spatial design is predicated upon our awareness of acoustic space as continuous and malleable through the efforts of sound designers. While traditional performance practices such as opera and ballet offer models for highly integrated visual-aural-spatial design, they do so in the rarefied environment of theatre. One trajectory for my own practice, now sublimated in an institutional spatial sound studio, is in part, moving toward collaborative projects seeking a similar integration in design projects. As Western societies finally acknowledge the environmental implications of their way of life, it is worth considering the ways that the acoustic environment might feature in this growing awareness. Perhaps there is a role for acoustic environment research and auditory spatial design to attune human consciousness to the implications of our actions not just on the soundscape, but also to the future conditions of built environments and natural landscapes.

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APPENDICES

Appendix 1: Original considerations from *CitySounds* report

The results of *CitySounds* Community Sound Survey have revealed potential opportunities for the City of Melbourne to consider for future planning and development.
These include investigating the possibility of providing quieter 'sites-of-respite' in the central business district for Melbourne's residents, workers and visitors. *CitySounds* survey findings may also inform the investigation and development of identified quieter City walking routes and the City's work with cafés and entertainment venues to ensure that the comfort and experience of customers is enhanced. Melbourne City residents might also value information on how to reduce sound in apartments. More information about ideas generated by the *CitySounds* survey for future City of Melbourne sound management activities are provided below.

1. Further investigation into the provision of sites-of-respite in the City

Sites-of-respite could be parkland, or developed around existing architectural conditions that protect them from major noise sources such as traffic, and plant and equipment (e.g. in courtyards or laneways). The network of arcades and laneways in the CBD, and spaces in the centre of City blocks could provide the basis of a series of sites-of-respite. *CitySounds* survey respondents identified these as quiet places in the CBD (Section B, Attachment 1). Sites-of-respite could link with walking routes through the CBD. Almost 70% of respondents reported that they would use a site-of-respite at least once a week or more often (Table 30). Other results indicate that usage would be highest if these sites were located within five minutes of home and/or office areas (Section F, Table 28). The types of usage reported (Section G, Table 29) suggest that to service public needs, these could operate during the day only.

2. Trial self-management strategies for quieter walking routes through the City

Over two-thirds of *CitySounds* survey respondents reported that they did not avoid parts of the CBD because of loud sounds (Section B). Yet a combined percentage (70.1%) reported they were annoyed by sounds in the CBD on an average day at a frequency of 'maybe once or twice' to 'every time they are outside'. This result should also be considered with responses for sound level reduction of loudspeakers used on the street (Section J, and General Observation 5). One interpretation of these results is that a new strategy combining acoustic design initiatives and an information campaign could provide CBD visitors and residents with the means to limit their exposure to annoying locations while walking around the City.

3. Quieter café campaign

Analyses indicate that CBD café and restaurant patrons would actively use information to select quieter cafés (Section E). An information campaign would obviously require the participation of café and restaurant owners prepared to manage their acoustic environments. Over half of *CitySounds* survey respondents felt that cafés had become noisier in the last three to five years (Table 21), and 35% thought this was due to their design and the increased use of glass and concrete surfaces (Table 22). A large proportion of survey respondents aged 35 years or over reported they recently had difficulty holding a conversation in a café or restaurant (77.8%) (Section E, Bullet point 5, *Age comparison*).

Choice would be a key element in an information resource, the main drivers being no change in price for better listening conditions, and the type of event or occasion they are attending (Table 27). The expectations of *CitySounds* survey respondents were reasonable; they did not expect every café to sound the same, as indicated by 89% of respondents expecting sound levels in cafés and restaurants to differ depending on their type (Table 23). Expectations of sound levels also changed depending on the nature and size of an event (Table 24).

CitySounds revealed differences in attitudes between CBD residents and non-residents, and between survey respondents of different ages. These should be considered in any targeted patron or industry campaigns. For example, Section E filter results revealed that 25.8% aged 35 years and under, thought that increased noise levels in cafés were attributable to music played too loudly, compared to 8.0% of respondents aged 35 years and over (Section E, Bullet point 2).

4. Enhancing patron experience in nightclubs by managing amplified music

The *CitySounds* survey asked respondents how often they visited nightclubs, and to consider their perception and experiences of sound within nightclubs. A majority of respondents reported they regularly visited nightclubs (64.1%, Table 33) and the music was loud (85.9% - Section I, Table 35). A slightly higher proportion reported that loud music was enjoyable (58.8%) compared to those that did not enjoy it (41.5%, Table 36). This depended on the age of respondents, with those aged 35 years and under more likely to enjoy loud music (63.8%) compared to people aged 35 years and over (43.6% - Section I, Bullet point 4, *Age comparison*).

However, 88.9% of *CitySounds* survey respondents believed that music should be managed so it is loud on the dance floor but quieter elsewhere to allow people to hold a conversation (Table 37). Such a high response indicates that sound management in nightclubs would significantly enhance, not diminish the experience for patrons. Possible flow-on effects likely to arise from controlling amplified music in nightclubs include reduced impact on residents living nearby entertainment venues.

5. Reducing the effects of street based loudspeakers on listeners

CitySounds survey respondents reported they would appreciate a reduction in the volume of amplified sound in the CBD, although not its total removal. Just over half of respondents reported that removing loudspeakers from city streets would either ‘extremely’ or ‘somewhat’ diminish the vibrancy of the City (51.6%), while 37% reported that removing loudspeakers would have ‘no effect’, or ‘slightly’ or ‘significantly’ enhance vibrancy (Section J, Table 39). While *CitySounds* respondents reported their annoyance to amplified music from shops to be evenly spread across the lower three levels of a given scale, over three-quarters (75.5%) reported that amplification should be "just loud enough to help me hear when I'm less than five metres to the loudspeaker" (Table 41).

6. Design of community and industry information and awareness campaigns

The *CitySounds* survey results and summaries could assist in targeting discrete groups based on demographic, economic or site use. Several examples are provided below:

Cafés

It is generally known that the adverse affects of background sound (known as 'the cocktail party effect') on listeners increases with age. In the age comparison of Section E (Cafés), there was no difference in opinion based on age that cafes had become noisier in the last three to five years, but respondents aged 35 years and over said they would be more likely to use information about sound levels in cafés (Section E, *Age Comparison, Bullet point 6*). A targeted information campaign to this demographic is likely to be more cost effective in any future initiatives.

Apartments

It would appear that *CitySounds* respondents are interested in assessing the acoustic conditions of their properties before purchasing and renting. Respondents reported that acoustic design features in apartments are very important to consider when buying or renting a property (67.2%), suggesting they would be open to more information on this topic. This would suggest that information campaigns would be most effective if built around the time of sale or renting property. For renters, the likelihood that a landlord would not make changes to an apartment should be considered in future information campaigns.

Context, choice and expectations

A key aim of the *CitySounds* survey was to determine broader community attitudes and awareness to sound issues than was currently available to Council via complaints about noise. Council seeked to determine the extent that complaints indicated the wider community's attitudes and expectations about sound in the CBD.

For example, in Section E (Cafés) 89.8% of survey respondents said they expected different cafés to have different sound levels; that is, not all cafés will, or should be quiet or loud. Similarly, their expectations of sound levels for different occasions were also reasonable, with a gradual decrease in expected loudness from large parties to intimate dinner. In Section B, 55.3% of survey respondents reported that current activity (ie. context) determines whether something they heard could be a noise or a sound (Table 4). Also reported in this Section, was that emotional states of being stressed, angry, unwell, tired or emotionally upset were times when respondents would be most affected by sound.

In general, *CitySounds* revealed that survey respondents had reasonable expectations of various contexts and sites. This should be considered in any future information and awareness campaigns to community and industry sectors.

7. Air-conditioners

The *CitySounds* data reported in Tables 10 - 13 indicate that a majority of survey respondents register awareness of air-conditioner sound in homes, the street, place of work or study and in cafes and restaurants. While *CitySounds* did not investigate levels of annoyance or interruption to daily activities, Council could consider further investigations, or consultation to more clearly determine the impact that air-conditioning sound has on listeners. By implementing sites-of-respite, Council could acquire a trial, or control site to further test the preferences of people within the CBD to these sites.

Apartments

Almost all *CitySounds* survey respondents reported that reducing sound levels entering their home would improve their lives (Table 14, Section D). This suggests they may be motivated to seek information on acoustic design, and the best time for targeting renters and property buyers with acoustic design information is at the point of sale or when commencing a new lease (see Table 18, Section D). Council could consider this when developing noise-related information campaigns. Council is currently addressing the communication of acoustic design information. The expected costs by *CitySounds* survey respondents for modifying a property to reduce sound exposure could be described as 'modest' (Table 15, Section D).

Appendix 2: Text from the *SoundSites* project

1. Philip conducts the city

"I feel like a conductor beating out a symphony on the city".

Sonic textures roll under Philip's cane as he navigates his way through the city. A rapid montage of clicks, scrapes and clutters.

2. & 3. Symmetry

Two moments of symmetry: a church bell and the
electronic beep of an automated teller machine; ocean waves and the hiss from an opening drink bottle.

Interview participants expressed a desire for a soundscape that allowed for small and large sounds, creating a rich and complex acoustic environment. The sounds in the two examples share qualities of pitch and timbre.

4. Bridges and trains

Sighted people use large, stable objects to orient themselves in space, to determine how far they have travelled, or how far they have to go. Unsighted people must listen for subtle clues coming from the same objects. On a train journey, an unsighted traveller might count the number of bridges passed, or the number of stops between stations.

This moment is recorded in a train as it passes under several bridges between two inner eastern suburbs. The number of bridges passed under is available at the entrance to the gallery.

5. Interlude - water ensemble

The hidden acoustic worlds of water unfolded, created from the moment, "Water ensemble". This moment is an interlude created from several electroacoustic music techniques.

6. & 7. Night and day

During night and day, the ambience of an environment changes. This moment shifts from recordings of cars on a suburban road, during day then night.

8. Sound walk 1 - through streets to a gallery

Streets, alleys, doorways, lanes, awnings, reflect sound back to the listener in a subtle composition of surface textures colouring the acoustic environment. Listen for the changes between open and closed sounds in various spaces and the changes of textures underneath the feet of the walker.

9. Birds

Many of the interview participants spoke about bird calls. Some people identified favourite calls and places where they could listen to a variety of birds. This moment was recorded close to the city, by the Yarra River.

A sonic panorama.

10. & 11. Two corners in a city - No 1 and 2

Learning to navigate spaces without vision requires continuous attention to smell, physical/muscular memory and sound. This moment contains two street corners from Melbourne, where each has a distinct character determined by sounding objects such as flagpoles, traffic direction and speed, trams, shops and changes in the background ambience.

In navigating the city, these differences map out the identity of the location.

12. Supermarkets

During one interview, a group of teenagers described the sounds of a supermarket. They kept trying to outdo each other with their observations of sounds from the check-out and the differences between sections within a supermarket. For example, the kitchen or crockery sections sound much brighter than the bedding or clothing sections.

13. Impulse - response 1

Listening to a doorway.

Find a doorway, move to one side, stand very close to the adjoining wall. Make a "click" with your tongue and listen. Now move directly in front of the doorway and make a "click", listen to the difference.

A simple exercise in listening to space.

14. Impulse - response 2

Surfaces respond to sounds in unique ways. When the sound bounces off the surfaces of a room, we are literally listening to that room. We make a short sound or impulse, and the room responds. The ability to hear the acoustic qualities of different spaces is an important navigational technique.

Three different rooms in a house.

15. The sonic shoreline

While walking along a street, windows, doorways and awnings effect subtle changes in the acoustic environment. A doorway is an acoustic thread between the inside and outside; you follow the thread or pass it by, counting the threads as landmarks on your journey.

Along a narrow street, counting doorways.

16. 17. & 18 Transitions - outside to inside

Transitions from outside to inside in three different arcades in the city. The variations in ambient sound between spaces form contours on a sonic map.

A small difference is heard between the ambience of the street and the interior of the first two arcades. In most contemporary shopping malls, sound bounces around their interiors in a way that "de-localises" the listener. The experience is a combination of blandness and frustration. The first arcade is flooded with machinery noise from outside. The soft hissing sound in the second arcade comes from nearby escalators.

The final example is an older style arcade, high ceiling and several types of surfaces that reflect the sound away from the listener. The difference between the busy street and the interior can be clearly heard.

19. Sound walk 2 - Botanical Gardens

Sounds from the gardens – birds and screeching bats. A brief respite from the city.

20. Kitchen

Shape, colour, resonant, warm, brittle, crackle, spill. A pattern of sounds recorded from adomestic environment that creates the acoustic identity of an everyday space.

21. & 22. Well-heeled

The sonic character of a location is coloured by the affluence of those who visit. Wealthy suburbs are often quieter because of more expensive, aerodynamically designed cars, tree lined streets and gardens.

Are dress codes audible?

The first recording was made at the entrance of a hotel on Collins Street, the second was made at the entrance to a university campus on Swanston Street. Leather-soled shoes traverse the entrance of the hotel, while at the university, rubber-soled shoes create a different ambience.

23. Interlude - Celestial Kitchen

An imaginative weave of sounds from the moment "Kitchen". This moment is an interlude created from several electroacoustic music techniques.

24. Sound walk 3 - waters edge

Sound travels fast and far over water. Sand underfoot, the masts of boats and small waves.

Appendix 3: Brief descriptions of other SIAL Sound Studio projects

Design Studios

Symphonic Home: Industrial Design, Frank Feltham and Jeffrey Hannam. This studio investigated the creation of interactive sound objects for the home.

Memory Games: Architecture, Professor Mark Burry, Gregory More, Jules Moloney and Lawrence Harvey. A games-based design studio where students constructed a realistic laneway of Melbourne, through which a visitor entered a world constructed from memory. The students also created extensive soundscapes for their project based on recordings from Melbourne.

Future Sound of Cities: Architecture, Jules Moloney and Lawrence Harvey. Historical envisioning of future soundscapes - whether Marinetti's Futurism, or Bacon's utopian vision of sound houses - relied on text as the medium of realisation, and the aural imagination of the reader. Utilising the StringCVE software environment, a suite of sound design tools and spatial sound technologies, participants realise sounding models of speculative virtual acoustic environments.

Museum of Sound: Interior Design, Nicholas Murray and Lawrence Harvey. Students were led through a series of exercises to curate a sound collection, for which they then designed a museum.

Electives

SSCAD (Spatial Sound Composition and Diffusion): an elective of the SIAL Sound Studios introducing concepts of spatial sound.

Soundscape Studies: an elective of the SIAL Sound Studios introducing and investigating topics in acoustic ecology.

Bouncing off Walls: interior design, Nicholas Murray. A design communication elective exploring a suite of tools and technologies for desktop acoustic design.

Selected Post Graduate research

Interfaces for Spatial Sound – Pete Brundle, Masters.
Modelling sounds for Japanese Gardens – Scott Brewer, Masters.
Theoretical acoustic and spatial models for architectural environments – Nicholas Murray, PhD.

Funded Research

The Spatial Ensemble: scaling instrumental resonance and morphology for spatialised performance.
Project team: Lawrence Harvey, Dr David Forrest and Richard Barrett. Industry partners are Elision Ensemble and the Judith Wright Centre of Contemporary Arts. Funded by the Australian Research Council. Despite the recent proliferation of enabling technologies for spatial sound design, the frequency of innovative public concerts based on these technologies is low. Expanding this cultural practice requires an integrated solution accommodating all stages of creation and production of a spatial sound performance, instrument research, development of a scaleable and flexible technology platform for diverse performance venues, and fostering of a research culture in contemporary performers. To fully exploit technology resources for delivering unique concerts, four PhD candidates will investigate diverse musical instrument resonance to integrate with new sound spatialisation strategies for public concerts.

TEIMU (the Garden of Dreams): Aural and Aesthetic Attributes of Japanese Gardens as Models for Spatial Environments.
Project team: Professor Peter Downton, Lawrence Harvey, Dr. Michael Fowler, Dr. Greg Missingham (Melbourne University), Alex Selenitsch (Melbourne University). Funded by the Australian Research Council. Traditional Japanese garden design has greatly influenced both 20th Century Western landscape designers and composers of Western art music. By investigating the aural and aesthetic attributes of five renowned Japanese gardens, RMIT and University of Melbourne researchers will seek out spatial sound designs that could enhance sound quality in urban environments and provide a pioneering approach to architectural modeling and the built environment. This project has long term cross-disciplinary implications. The results and methods contained in this project may assist in innovative sound design for new media applications, better listening environments in urban areas, unique approaches for data modeling, and a catalyst for future design strategies.

Urban Soundscape Group

A case study of five large-scale soundscape systems in Melbourne's CBD, development of an automated control platform for soundscape systems, and the design of creative works for in-house and public soundscape systems. The case study is designed to establish base line knowledge on the management of large-scale urban soundscape systems including development of content, strategies for setting design criteria, evaluation of complete works, processes for critique and feedback and frameworks for content design into the future. With early planning of new precincts in the CBD under way, opportunities are being explored for installation of new systems using the investigation of the case studies as background. Project team includes; Lawrence Harvey, Jeffrey Hannam, Philip Samartzis and Darrin Verhagen. The Research Assistant is Nicole Forster.

Contract Research

Auditory City Concerts: a series of three free lunchtime concert performances in Melbourne, exploring different performance locations and settings. The three concerts were:

1	Location – Melbourne Town Hall – 2.10.2007
	Title – *Eight panels for organ and electronics duration – 45 mins*
	Structured improvisation with graphic score – Andrew Blackburn (organ), Jeffrey Hannam (electronics) and Lawrence Harvey (spatialisation)
2	Fullham Lane (off Flinders Lane between Elizabeth and Queen Sts.) – 9.11.2007
	Artemis, Goddess of nature, the animal kingdom, the hunt and fertility
	Composer – Karen Heath
	Performers – Karen Heath (clarinet), Lawrence Harvey (sound diffusion)
3	Signal, Northbank – 16.11.2007
	SPIRAL
	Composer – Karlheinz Stockhausen
	Performer – Michael Fowler, Doepfer analog keyboard, KorgMicro keyboard, electronics

CitySounds 1.0: discussed extensively in Chapter 5.

CitySounds 2.0: a contract research project for the City of Melbourne, to create an interactive tool for presenting guidelines for best acoustic design of apartments.